EIGHTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN

For the year ending June 30, 1891.

MADISON, WISCONSIN:
DEMOCRAT PRINTING COMPANY, STATE PRINTERS.
1892.

Dairy School Building, University of Wisconsin.

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☞The Bulletins and Annual Reports of this Station are sent free to all residents of the State who request it.

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Office and Laboratories, in Agricultural Hall, University Grounds.
Experiment Farm, with buildings, joins the college grounds on the west.
Telephone connection.

LETTER OF TRANSMITTAL.

MADISON, Wis., October 1, 1891.

To His Excellency, GEO. W. PECK,

Governor of Wisconsin:

I have the honor to transmit to you herewith, in accordance with law, the Eighth Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

WM. P. BARTLETT,

President of the Board of Regents,

University of Wisconsin.

REPORT OF THE DIRECTOR.

In presenting the Eighth Annual Report of the Agricultural Experiment Station to the farmers of our state, I take this opportunity of noting some of the steps of progress in our work.

The new dairy school building.—Members of the last legislature were frequent and interested visitors at our dairy house; all were struck with the lack of room for so large an attendance, and we were promised more commodious quarters. A generous appropriation was made to the university for needed buildings, the dairy school being specified in the list. The regents of the university, with characteristic good will toward this department, arranged that the dairy school should be the first of the new builings erected, and directed that if possible the first floor should be ready for students by the beginning of the year 1892. Facing the title page of this report is a perspective view of the Hiram Smith Hall, as this building is most appropriately named. A description of it will be deferred to a later report, as it is still incomplete. This building is planned both for dairy instruction and investigation, and adds very materially to the possibilities of the Station in the line of dairy work.

The Babcock milk test.—Our Seventh Annual Report contained a description of the Babcock milk test, an instrument by means of which the fat in a sample of milk, skim milk, butter milk, whey or cheese, may be accurately and quickly determined by dairymen and factory operators. Although the bulletin announcing this test was only issued July, 1890, several firms have already taken up its manufacture and thousands of dairymen and factorymen have begun studying dairy operations on the farm and in the factory in a manner heretofore practically impossible, because of the lack of a proper instrument for quickly

and accurately measuring the fat in milk. Athough the interest in the test is already widespread and deep, as will be seen by referring to the columns of any agricultural or dairy paper, I believe that even yet none of us fully appreciate its value to the dairy interest. I fully believe the Babcock milk test is worth to Wisconsin each year many times the whole cost of this Station. It was given to the dairy world without restriction by patent, or limitations in any way.

Sheep investigations.—No excuse is offered for the considerable amount of space given in this report to sheep investigations. What we have done is but an earnest of our purpose in the future work. Next to her dairy interests, Wisconsin should foster sheep husbandry. While we may not be able to compete with the arid districts of the world in the production of fine wool, no section of America has greater advantages in the way of markets for fine mutton, and I doubt if any has superior natural regions for feeding mutton sheep. Not only have we within our state thrifty cities and villages, but all around the borders are great commercial, mining, and manufacturing centers, with enormous consumptive capacity. These markets should be supplied with mutton of the finest quality from Wisconsin farms. There are millions of acres of land in our state preeminently adapted to this animal, and this vast area will never serve its highest purpose until it is fed over by fine mutton sheep. To point out one section specifically, I would mention the hilly bluff lands extending many miles back from the Mississippi river, as a district peculiarly adapted to the mutton sheep. Most of these lands have very considerable fertility, and sheep farms need not be large in order to feed a sufficient number of animals to maintain a profitable and well arranged sheep farm. Most fortunately mutton sheep cannot be successfully kept in large flocks; only in small divisions, carefully watched over and attended by intelligent keepers, will they prove profitable. It is small farms that make a state prosperous and progressive. Just as dairy farms must always continue small in comparison with grain farms, so the sheep farms should

not be large to get the highest results. Judging from census reports, we probably have only about a million sheep in Wisconsin at this date. Not until our assessors report at least three million sheep within our borders will this Station have done its duty by this single interest.

The Station work.—The several lines of work undertaken by us are shown under appropriate headings. If the farmer and gardener does not find within the covers of this report that which particularly bears upon his leading interest, I ask forbearance under the plea that even now we have in progress more lines of work than our finances and the list of workers of our Station force warrant. There is a constant tendency in an institution like ours to spread out too much, and in spreading the work becomes so thin in character and quality as to be of little value. Only by concentration along a few lines can we reach results that will stand, and it is by holding to this plan rigidly that we hope to build up a station that shall have recognized value among the great agricultural forces in our state.

Our annual report.—Through the generous action of our last legislature, the possible limit of our report is increased from 250 to 350 pages, and the number of copies from 12,000 to 15,000. A portion of these reports are distributed through members of the legislature and other state officers. Our carefully revised mailing list now contains about 8,000 names of residents of Wisconsin who have by letter solicited the annual reports and quarterly bulletins. We still hold good the offer that reports and bulletins will be sent free to all residents of the state upon request.

The status of the Station and its work.—The live stock interests of this state must always remain the leading feature in agricultural progress, and recognizing this, the Station has increased its working force by adding thereto Prof. John A. Craig, a graduate of the Ontario Agricultural college, under whose especial charge the sheep investigations of this Station are placed. Many stations have suffered severely through constant changes going on in the working force. No doubt this is an almost

necessary incident in the rapid rise of investigational work in this country, but it is much to be deplored. I am pleased to state that no changes have occurred in our membership, and to this fact is due, I believe, much of whatever we may have been able to accomplish. While there has been continuity of effort and steadiness of purpose within, we have received aid and encouragement from without. Our state authorities, as already noted in these pages, have dealt most generously with us. The regents of the university and its president have taken the kindliest interest in our work, and stop at nothing within their power to push it forward. Best of all, the farmers of Wisconsin are showing more and more interest in our work. In evidence of this our very large correspondence bears testimony, as does the steadily increasing list of visitors. It is the earnest desire of all connected with the Station that we may merit the continued good will and support of all the friends of progressive agriculture.

SHEEP FEEDING TRIALS: NOTES ON CROSS BREEDING SHEEP.

JOHN A. CRAIG.

I. WINTER RATIONS FOR BREEDING EWES. A FEEDING EXPERIMENT WITH HAY, CORN FODDER, OAT STRAW, CORN SILAGE, CLOVER SILAGE AND SUGAR BEETS.

In conducting this experiment our aim was to collect data bearing on the relative value of the different common fodders that are frequently used for feeding breeding sheep during the winter season. Besides weighing the sheep weekly and keeping strict account of all food eaten, we noted, as closely as our observation would permit, the effects of the different foods on the thrift of the sheep, their influence in the condition of the wool, and still further, the differences in the milk secretion of the several lots. Our breeding flock of twenty-four high grade Shropshires, very uniform in type and wool, were divided into two groups, each made up of three lots with four ewes in a lot. The ewes were on experiment for eight weeks during the period beginning January 21st and ending March 18th.

To avoid unneccessary repetition, we give here the scale of prices adopted in valuing the different foods used in this and other experiments. The prices are the average for the state, and will vary somewhat according to locality:

Corn fodder	20 cents per 100 lbs.,	$4.00 per ton.
Oat straw	15 cents per 100 lbs.,	3 00 per ton.
Clover hay	40 cents per 100 lbs.,	8.00 per ton.
Hay (blue grass)	40 cents per 100 lbs.,	8 00 per ton.
Corn silage	10 cents per 100 lbs,	2.00 per ton.
Clover silage	10 cents per 100 lbs.,	2.00 per ton.
Sugar beets	10 cents per 100 lbs.,	2.00 per ton.
Bran	60 cents per 100 lbs.,	12.00 per ton.
Oats	88 cents per 100 lbs.,	30c. per bu.
Corn	71 cents per 100 lbs.,	40c. per bu.
Oil meal	$1.00 per 100 lbs,	$20.00 per ton.

GROUP I.—COMPARISON OF DRY FODDERS.

The dry fodders experimented with in these trials were oat straw, hay, (mostly blue grass) and cut corn fodder. The ewes were divided into three lots with four in each. At the beginning of the experiment the total weight of the ewes in Lot I was 617 lbs., those in Lot II 622 lbs., and those in Lot III 593 lbs. All the lots were fed the same quantities of grain and sugar beets. In addition, those in Lot I received cut corn fodder, those in Lot II oat straw and those in Lot III meadow hay; in each instance as much as they would eat. The ewes were never forced, the object being to keep them in thrifty breeding condition. During the period of eight weeks, each of the three lots consumed 704 lbs. of sugar beets, and 112 lbs. of oats and bran. In addition, during that time they ate the following amounts of these fodders that make the distinctive differences in their rations:

Table showing fodder eaten and increase in the live weight of breeding ewes fed for maintenance.

WEEK ENDING	LOT I.			LOT II.			LOT III.		
	Corn fodder.		Gain (+) or loss (—)	Oat straw.		Gain (+) or loss (—)	Hay (Blue Grass).		Gain (+) or loss (—)
	Eaten.	Refuse.	Lbs.	Eaten.	Refuse.	Lbs.	Eaten.	Refuse.	Lbs.
Jan. 28	71	27	+17	37	13	+4	58	8	+ 6
Feb. 4	51	14	—11	31	7	—6	44	3	— 8
Feb. 11	69	24	+20	35	15	+5	50.5	3.5	+19
Feb. 18	41	9	—14	31	9	0	39	1	— 5
Feb. 25	40.5	9.5	+ 8	32	8	+1	38.5	1.5	+ 2
Mar 4	40.5	7.5	+ 1	32	8	+3	38.5	1.5	+ 4
Mar. 11	42	6.0	+11	33	7	—1	36.5	2.5	+ 2
Mar. 18	37.5	6.5	+ 3	31.5	8.5	—2	38	2	— 1
8 weeks	392.5 lbs.	103.5 lbs.	+35 lbs.	262.5 lbs.	75.5 lbs.	+4 lbs.	343 lbs.	23 lbs.	+19 lbs.

As far as the eye and hand could discern, those in Lot I given cut corn fodder were the most thrifty. They had a much healthier appearance than the other lots and this was especially noticeable in their fleeces, more particularly when contrasted with those receiving straw in Lot III. The fleeces of the latter were somewhat fluffy, while those of Lot I were were in a much better condition, being more elastic and brighter.

A critical examination of all the ewes that had lambed before being put on pasture showed that those of Lot I fed corn fodder were doing the best in respect to the secretion of milk, Lot III fed hay nearly as good, and Lot II getting the straw ration the poorest of the three lots. As some of the ewes were later than the others in lambing, they were kept on their distinctive rations until they dropped their lambs. With the exception of one ewe in each lot, they all dropped their lambs some time before grass was ready for them. All the ewes, with the exceptions noted, had single lambs, and none of the latter were indifferently reared.

COST OF RATIONS.

We give a detailed statement that will make clear the difference in the cost of these rations and also indicate the cost of maintaining breeding ewes during the housing season.

Cost of rations used in maintaining four breeding ewes, during eight weeks.

Lot I. (Corn Fodder.)

392.5	lbs. corn fodder at 20 cts. per 100 lbs	.78
704	lbs. sugar beets at 10 cts. per 100 lbs.	.70
56	lbs. oats at 88 cts. per 100 lbs.	.49
56	lbs. bran at 60 cts. per 100 lbs.	.33
	Cost of maintaining four ewes eight weeks	$2.30
	Cost of maintaining one ewe one day	1c.

Lot II. (Oat Straw,)

262.5	lbs. oat straw at 15 cts. per 100 lbs.	.39
704	lbs. sugar beets at 10 cts. per 100 lbs.	.70
56	lbs. oats at 88 cts. per 100 lbs.	.49
56	lbs. bran at 60 cts. per 100 lbs.	.33
	Cost of maintaining four ewes eight weeks	$1.91
	Cost of maintaining one ewe one day	$\frac{4}{5}$c.

Lot III. (Hay.)

343	lbs. hay at 40 cts. per 100 lbs.	$1.37
704	lbs. sugar beets at 10 cts. per 100 lbs.	.70
56	lbs. oats at 88 cts. per 100 lbs.	.49
56	lbs. bran at 60 cts. per 100 lbs.	.33
	Cost of maintaining four ewes eight weeks	$2.89
	Cost of maintaining one ewe one day	1$\frac{1}{5}$c.

It is shown in the foregoing estimate that the ration of oat straw fed Lot II was considerable cheaper than the ration of corn fodder fed to Lot I, while that fed to Lot I was much more economical than the hay ration received by Lot III. The low cost of these rations, which contained more grain than is usually fed except for a short period preceding lambing, gives credit to the statement that the cost of maintaining breeding ewes is covered by the wool they produce.

GROUP II. COMPARISON OF SUCCULENT FODDERS.

This group was also made up of three lots each containing four ewes. In this trial the object was to make a comparison between the succulent fodders, corn silage, clover silage, and sugar beets. The ewes were fed just enough of these to keep them in breeding condition. At the beginning of the experiment the total weights of the lots were: Lot IV, 622 lbs., Lot V, 608 lbs., and Lot VI, 617 lbs. They all received equal quantities of similar grain and hay, the only difference in the rations being that Lot IV received corn silage, Lot V sugar beets, and Lot VI clover silage. In all cases they were given as much of the succulent foods as

they would eat. Though all the lots were fed the same quantities of hay, they yet differed slightly in the amount eaten. Lot IV at 326.2 lbs., Lot V 337.5 lbs., and Lot VI 347.7 lbs. These differences are due to the fact that though each of the lots was fed six pounds daily the amount of refuse varied. These variations in the quantity of hay may be set against the differences in gain and thus be practically ignored.

AMOUNT OF FOOD EATEN.

The following gives the amounts that were eaten, of the fodders peculiar to the different rations and also shows the gain or loss in weight of each lot:

Table showing fodder eaten and increase in live weight of breeding ewes fed for maintenance.

WEEK ENDING.	LOT IV.			LOT V.			LOT VI.		
	Corn silage.		Gain (+) or loss (—)	Sugar beets.		Gain (+) or loss (—)	Clover silage.		Gain (+) or loss (—)
	Eaten. Lbs.	Refuse. Lbs.	Lbs.	Eaten. Lbs.	Refuse. Lbs.	Lbs.	Eaten. Lbs.	Refuse. Lbs.	Lbs.
Jan. 28	87	1	+ 7	112	....	+ 6	48	19	+11
Feb. 4	88.5	1.5	+ 1	112	....	+ 3	39	23	+ 1
Feb. 11	93	1	+14	112	....	+16	107	36	+17
Feb. 18	50	....	—11	84	....	— 4	92.5	6.5	— 2
Feb. 25	50	....	+ 5	84	....	— 3	78	1	— 3
March 4	50	....	+ 4	84	....	+ 3	79.5	.5	+ 8
March 11	47.5	....	+ 5	84	....	+16	78.75	1.25	+ 3
March 18	44	....	—12	84	....	— 9	78	2	— 6
8 weeks	510 lbs.	3.5 lbs.	+13 lbs.	756 lbs.	....	+28 lbs.	600.75 lbs.	89.25 lbs.	+29 lbs.

The difference in the thriftiness of the ewes was not so marked in this group as in the other. If anything, appearances were in favor of the lots that were fed silage with the advantage on the side of those receiving clover silage. The difference existing between the lots in the flow of milk was more defined. Repeated examination of the udders of the ewes showed that those in Lot VI, fed on clover silage were giving the most milk, with those in Lot IV, fed corn silage coming next, and Lot V, fed on sugar beets ranking last. The individuality of the ewes would be, however, a strong factor in influencing the effects of these rations on the flow of milk.

Cost of rations used in maintaining three groups of four breeding ewes during eight weeks.

Lot IV. (Corn Silage).

510 lbs. corn silage at 10 cts. per 100 lbs	$.51
336 lbs. hay at 40 cts. per 100 lbs	1.34
56 lbs. oats at 88 cts. per 100 lbs	.49
56 lbs. bran at 60 cts. per 100 lbs	.33
Cost of maintaining 4 ewes 8 weeks	$2.67
Cost of maintaining 1 ewe 1 day	.01$\frac{1}{10}$

Lot V. (Sugar Beets).

756 lbs. sugar beets at 10 cts. per 100 lbs	$.75
336 lbs. hay at 40 cts per 100 lbs	1.34
56 lbs. oats at 88 cts. per 100 lbs	.49
56 lbs. bran at 60 cts per 100 lbs	.33
Cost of maintaining 4 ewes 8 weeks	$2.91
Cost of maintaining 1 ewe 1 day	.01$\frac{3}{10}$

Lot VI. (Clover Silage).

600.3 lbs. clover silage at 10 cts. per 100 lbs	$.60
336 lbs. hay at 40 cts. per 100 lbs	1.34
56 lbs. oats at 88 cts. per 100 lbs	.49
56 lbs. bran at 60 cts. per 100 lbs	.33
Cost of maintaining 4 ewes 8 weeks	$2.76
Cost of maintaining 1 ewe 1 day	.01$\frac{1}{5}$

In the matter of cheapness it is clear that corn silage leads the others. These differences in cost, though appear-ing slight when reduced to the daily cost of maintaining a ewe would grow into considerable amounts when applied to a flock during the housing season. Corn silage and clover silage were found to be excellent foods for breeding ewes. The corn silage is a cheap, palatable and healthy food. The sheep soon began to like it, and undoubtedly it contributed largely to their healthiness during the period of experiment. A careful examination of the teeth of all those fed silage failed to discover any traces of corrosion likely to have been caused by the acidity of the silage.

CONCLUSIONS.

1. In the experiment with dry fodders, cut corn fodder gave the best results as the ewes so fed were maintained cheaply, they kept in the best health, their fleeces were in the best condition and after lambing they gave the most abundant supply of milk.

2. Oat straw as a fodder for sheep is shown by this experiment to have a higher feeding value than is commonly credited to it. Combined with a small quantity of grain and succulent food it offers the best ration for carrying breeding ewes over winter at the least expense. Ewes were kept in good condition on a ration consisting largely of it at a cost of less than a cent a day. It is shown in the able giving the food consumed, that the amounts of corn-fodder and oat straw refuse are very similar; as the ewes fed corn fodder left 20 per cent. of the fodder that was fed to them, and those that received oat straw left 22 per cent. of waste. While it would not be proper to recommend an exclusive straw and grain ration on this trial alone yet it is evident that oat straw may be with profit more largely used with other fodders.

3. While hay is a good dry fodder for sheep, yet, looking for the best results and closest economy, it would be better to give the preference to oat straw and corn fodder, where these fodders are available at the valuation given in our scale of prices.

4. Corn silage is a valuable fodder for breeding ewes, surpassing the other succulent fodders used in this experiment in its cheapness, by keeping the sheep in good thriving condition, and leading to a good flow of milk.

5. Clover silage, if properly preserved, is a good sheep food. The sheep, after getting used to it, eat it with avidity, and do well on it. Against it is the cost of making and the difficulty in preserving it.

6. Sugar beets are liked by sheep, but they cannot be said to equal either of the other succulent fodders experimented with. They are apt to induce scouring if fed in quantities of over four pounds daily to each ewe.

II. INFLUENCE OF DIFFERENT RATIONS ON THE GROWTH OF WOOL AND INCREASE IN LIVE WEIGHT OF FATTENING SHEEP.

In this experiment we sought for facts that would enable us to determine the influence of specific rations upon the growth of wool and the increase in live weight. The general plan of the experiment is very similar to that conducted by Prof. Henry at this Station last year with the exception that only two different rations were fed in this instance while three were tried in the other. The wethers selected for this experiment were twelve Shropshire grades averaging about nine months old at the time the experiment was begun. They were all shorn December 12 to make the conditions favorable for a study of the effects of the different rations upon the wool growth. The average clip of the twelve wethers was 5.1 lbs. After being shorn they were divided into Lots I and II, of which the former averaged 82.6 lbs. in weight, and the latter 86.6 lbs. when the experiment was begun.

RATIONS FOR THE TWO LOTS.

Lot I received a carbonaceous ration consisting of shelled corn, cut corn fodder and corn silage. Lot II was fed a nitrogenous ration composed of oats and oil meal mixed equally by weight, clover hay and clover silage. The wethers in the two lots were fed as much as they would eat

of both the grain and coarse feed. The nutritive ratio of the ration fed to Lot I was 1:10, while that fed to Lot II was 1:3.6. After feeding them for two weeks on their distinctive rations to accustom them to the different foods, the experiment was begun January 19 and lasted until April 13, a period of twelve weeks. The conditions surrounding both lots were identical. The table that follows shows the quantities of food eaten by each lot together with the weekly gain in live weight:

Table showing the amount of food eaten and the increase in live weight.

	Lot I. Nutritive ratio 1:10. Six wethers fed shelled corn, corn silage, corn fodder.				Lot II. Nutritive ratio 1:3.6. Six wethers fed oats and oil meal, clover silage, clover hay.			
Week ending	Shelled corn.	Corn silage.	Corn fodder.	Gain.	Oats and oil meal.	Clover silage.	Clover hay.	Gain.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
January 26	38	29.5	46	18	40	63.5	46.5	14
February 2	53	29	44	12	58	90	49	15
February 9	60	33	50.5	19	60	133	47	24
February 16	60	41	49	18	64	125	45	12
February 23	60	35	44.5	3	64	144	48	18
March 2	63	33	47	4	69	139	46	14
March 9	61	37	56.5	30	67	157	45	11
March 16	62	31	62.5	15	74	141	54	16
March 23	65	31.5	62.5	22	75	170	53	28
March 30	64	38.5	63	9	81	199	45.5	18
April 6	57	36	63.5	16	92	186	46.5	33
April 13	60	35.2	66.5	15	92	191	44	11
Twelve weeks	703	409.7	655.5	181	836	1,738.5	569.5	214

The foregoing table shows that Lot II made a total gain in live weight of 33 lbs. more than Lot I during the period of twelve weeks. It should be stated that in Lot I. there were two wethers, Nos. 360 and 356, that did not develop as they should have done had they been thrifty. They were never unwell, yet, they were always poor feeders. During the period they only gained 24 lbs. and 25 lbs. respectively. In Lot II there was one wether, No. 350, that was also unthrifty, as it only gained 26 lbs. during the experiment. Had these wethers been of average vigor the cost of gain would have been materially reduced and the difference between the lots in the total gain might have been much less.

The only noteworthy fact bearing on the attitude of the wethers towards the foods making up their ration, is that at times, the appetites of the wethers in Lot I apparently became cloyed, causing them at intervals to show a slight indifference to corn silage. This was likely due to the limited variety of foods in the ration containing it. The wethers in Lot II always relished their ration. After a short preliminary feeding Lot II readily ate the clover silage, and they continued to like it throughout the experiment. The corn silage, except as noted above, was largely eaten by the wethers of Lot I, and it had a beneficial effect on their general health.

Cost of gain.

Lot I. Six wethers fed shelled corn, corn silage, and corn fodder, consumed during twelve weeks.

703 lbs. corn at 71 cts. per 100 lbs. (40 cts. per bu.)	$4.99
409 7 lbs. corn silage at 10 cts per 100 lbs. ($2 per ton)	.40
655.5 lbs. corn fodder at 20 cts. per 100 lbs. ($4 per ton)	1.31
Cost of 181 lbs. gain in live weight including wool	6.70
Cost of 100 lbs. gain in live weight including wool	3.70

Lot II. Six wethers fed oats and oil meal, clover silage and clover hay, consumed during twelve weeks.

418 lbs. oats at 88 cts. per 100 lbs. (30 cts. per bu.)	$3.67
418 lbs. oil meal at $1 per 100 lbs ($20 per ton)	4.18
1738.5 lbs. clover silage at 10cts. per 100 lbs. ($2 per ton)	1.75
569.5 lbs. clover hay at 40 cts. per 100 lbs. ($8 per ton)	2.27
Cost of 214 lbs. gain in live weight including wool.	11.85
Cost of 100 lbs. gain in live weight including wool	5.53

Considering the cost of gain made by the two lots, we find that Lot I increased in live weight at a rate of $1.80 cheaper per 100 lbs. gain than Lot II. In the experiment of a similar nature conducted last year the lot fed a carbonaceous ration made not only the cheaper gain, but also slightly the greater.

EXAMINATION OF THE WOOL.

In the tables that have been given the gain in wool has not been separated from the increase in live weight for the manifest reason that it would make the cost of gain unfairly high. As the wethers were shorn December 12th, and again on April 24th, when the experiment was completed, it is possible to separate the results in wool growth from those bearing on the increase in live weight. A statement of the length and weight of wool together with the shrinkage when tub washed is given. The wool was measured half-way between the top of the shoulder and the elbow. It was tub washed in soft water at a temperature of 76° Fahr. As the yolk is dissolved by warm water the losses of the fleeces through washing afford a basis for a comparison of the amount of yolk contained in each.

Table showing the growth of wool during the period of twelve weeks.

Lot I. Six wethers fed shelled corn, corn silage and corn fodder.

No. of wether.	Length of staple.	Wool, unwashed.	Wool, tub washed.	Per cent. loss in washing.
	Inches.	*Lbs.*	*Lbs.*	
346	1.50	3.3	2.3	30.3
359	1.50	3.4	2.2	35.2
146	2	3.5	2.6	25.7
349	1.75	2.6	1.6	38.4
360	1.50	3.5	2.5	28.5
356	1.50	2.5	2	20
Averages	1.6	3.1	2.2	29.7

Lot II. Six wethers fed oats and oil meal, clover silage and clover hay.

No. of wether.	Length of staple.	Wool unwashed.	Wool tub washed.	Per cent. loss in washing.
	Inches.	*Lbs.*	*Lbs.*	
357	1.25	3.9	2.4	38 4
347	2.	3.6	2.3	36.1
140	1.50	3.6	2.7	25.
345	2.	3.9	2.5	35.8
350	2.	3.1	2.3	25.8
355	1 50	3.3	1.8	45.4
Averages	1.7	3 5	2.3	34.5

The total difference of 2.6 lbs. in the weight of the fleeces of the two lots is striking to arise in such a short period. The results of the tub washing show that the difference in weight was due in a limited degree, to the amount of yolk in the fleeces of the lots. The fleeces of Lot I showed a loss about 30 per cent., while those of Lot II lost about 35 per cent.; still Lot II produced slightly more washed wool than Lot I.

RESULTS AT SLAUGHTERING.

The wethers in both lots were killed shortly after the experiment ended, and the weight of the blood, caul fat, intestinal fat, heart, lungs, skin, kidneys, together with the length of the small and large intestines were all carefully noted and are given in the following table:

Table giving the results of slaughtering the wether lambs used in this experiment.

LOT I.	Live weight.	Blood.	Heart.	Lungs.	Liver.	Kidneys.	Skin.	Caul fat.	Intestinal fat.	Length of small intestines.	Length of large intestines.	Dressed weight.
No.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Ft. In.	Ft. In.	Pr ct.
359......	131	4.0	.4	1.7	2.2	.20	7.4	5.5	2.6	76 11	22 10	53
349.........	117	4.2	.9	1.8	1.9	.20	4.2	3.9	1.4	67	23 6	48.7
146.......	113	4.0	.4	1.8	1.8	.25	7.1	2.0	1.8	88	23 3	46.4
346.........	118	4.2	.4	1.5	1.9	.25	7.2	3.9	1.8	79	23 4	51.6
360.......	98	3.6	.4	1.4	1.6	.20	8.0	2.1	.9	75	20	47.8
356.........	95	.....	.3	1.4	1.3	.20	6.5	2.5	1.1	73	19 3	46.8
Average.	112	4.	.46	1.6	1.78	.21	6.7	3.3	1.6	76 5	22	49.
LOT II.												
345.........	99	4.0	.3	1.6	1.7	.2	6.4	2.7	1.5	82	18	47.7
347.........	140	4.7	.5	1.7	2.1	.3	12.0	4.2	1.8	92 6	21 8	51
140.........	134.5	5.0	.5	2.1	2.2	.3	7.4	5.5	2.6	92 6	25	52.4
355.........	108	4.1	.4	1.5	1.6	.25	3.9	3.1	1.2	77	19 2	51.8
357........	124.5	4.7	.4	1.8	2.0	.3	8.2	3.9	1.8	80	23 4	51.8
350.......	106	4.2	.4	1.7	1.8	.25	6.7	3.5	1.1	84 11	21	50.7
Average.	117	4.45	.41	1.7	1.9	.26	7.4	3.8	1.6	87 4	21 4	51.

The average weight of the blood, lungs, skin, caul fat and the length of the small intestines of Lot I was slightly greater than that of Lot II, while the latter lot exceeded Lot I in the average weight of the heart and the average length of the large intestines. The differences, however, in all cases are exceedingly small.

The carcasses, after being dressed and hung up over night to stiffen, were cut into two sections just back of the fifth rib. No uniform differences in the mixture of fat and lean could be noted as existing between the two lots. With the exception of two carcasses all the flesh was nicely marbled.

RESULTS OF THIS TRIAL.

1. The cheaper gain was made by the wethers that were fed the carbonaceous ration of whole corn, cut corn fodder

and corn silage. The wethers in this lot gained 181 lbs. at a cost of $3.70 per 100 lbs., while those of Lot II given the nitrogenous ration increased in live weight 214 lbs. at a cost of $5.53 per 100 lbs., a difference in favor of Lot I at the rate of $1.80 per 100 lbs. gain.

2. The greater gain in live weight was made by the wethers that were fed the nitrogenous ration of oats and oil meal, clover silage and clover hay. The lot so fed gained 214 lbs. during the period, while the lot receiving the carbonaceous ration gained 181 lbs.

3. Slightly better results in wool growth were obtained from the wethers that were fed the nitrogenous ration as they clipped a total of 2.6 lbs. unwashed and .8 lbs. washed wool more than those fed the carbonaceous ration. The difference in the weight was due almost altogether to the greater amount of yolk in the fleeces in the wethers that received the nitrogenous ration. The fleeces of Lot I, lost 29 per cent. of its weight in the tub washing, and that of Lot II, 34 per cent.

4. There was no uniformity in the differences of the lots in regard to the mixture of fat and lean in the carcasses. As the wethers were almost full grown and the period of feeding somewhat short, it was not expected that any marked differences in the character of the flesh of the lots would arise.

5. Both clover and corn silage proved satisfactory food for fattening wethers. As observed in the experiment of last year these foods have a very beneficial effect on the thriftiness of the sheep to which they are fed. The corn silage will give the best satisfaction as it can be preserved better and made cheaper. The clover silage is well liked by the sheep, however, as may be seen from the fact that only 18 per cent. of that fed was left as refuse, while about 40 per cent. of the corn silage was left by the wethers receiving it.

RESULTS OF A PREVIOUS TRIAL.

In the first trial conducted by Prof. Henry during the winter of 1890 results were obtained that agree in the main

with those of the last trial. It was found in the first trial, as in the second, that the carbonaceous ration gave the cheaper gain, for Lot I fed on that ration made a gain of 98 pounds at a cost of $3.28, while Lot II fed the nitrogenous ration, made a gain of 92 pounds, at a cost of $4.96. In the second trial, however, the nitrogenous ration gave the greater gain which was not so in the first trial. In both trials no difference could be noticed in the mixture of fat and lean meat in the carcasses of the lots fed these rations. In both cases the trials were of rather short duration. As the figures are interesting, we give a brief statement based on these trials, of the feed required and cost of producing 100 pounds gain in fattening wether lambs:

Table showing food required and cost of producing 100 lbs., gain based on two trials with wether lambs.

1890.		1891.	
Nitrogenous ration (Lot III.)		Nitrogenous ration (Lot II.)	
Nutritive ratio 1 : 4.5.		Nutritive ratio 1 : 3.6.	
Amount.	*Cost.*	*Amount.*	*Cost.*
302 lbs. clover hay at 40 cts. per 100 lbs.	$1.20	266 lbs. clover hay at 40 cts. per 100 lbs.	$1.06
416 lbs. clover silage at 10 cts. per 100 lbs. ...	.41	812 lbs. clover silage at 10 cts. per 100 lbs. ...	.81
369 lbs. oats at 88 cts. per 100 lbs	3.24	195 lbs. oats at 88 cts. per 100 lbs	1.71
89 lbs. oil meal at $1.20 per 100 lbs. ...	1.06	195 lbs. oil meal at $1.00 per 100 lbs	1.95
27 lbs. potatoes ...	.18		$5.53
	$6.09		
Carbonaceous ration (Lot I.)		Carbonaceous ration (Lot I.)	
Nutritive ratio 1 : 9.7.		Nutritive ratio 1 : 10.	
381 lbs. corn at 71 cts. per 100 lbs.......	2.72	388 lbs. corn at 71 cts. per 100 lbs.......	2.75
296 lbs. corn silage at 10 cts. per 100 lbs.	.29	226 lbs. corn silage at 10 cts. per 100 lbs.	.23
158 lbs. corn fodder at 20 cts. per 100 lbs.	.31	262 lbs. corn fodder at 20 cts.......	.72
22 lbs. potatoes.....	.14		$3.70
	$3.46		

This statement in a slight degree affords a means of measuring the profit that may be made from fattening mutton sheep for market. It is to be remembered that each pound of gain during the fattening period adds to the

value of every other pound that the sheep weighs. A lamb weighing 75 lbs., costing 4 cts. per lb., is put in to fatten, and by the next spring it weighs 125 lbs., and then sells for 6 cts. per lb.; thus, the fifty pounds gain made during the fattening process increases the value of the original seventy-five pounds from 4 cts to 6 cts. This cannot be shown in estimating the cost of gain as given in the preceding statement. Further it is evident that the gain of these wethers was made during the period that it would cost the most, as the growing gain they would make on good pasture would cost less than that made on such comparatively costly foods as those that are fed in finishing them for market. As may be noticed the foods fed have been charged at good market prices. The figures will show that not only does the fattening of sheep supply the farmer with a steadily and easily accessible market on his farm for some of his farm produce, but also yields him a good margin of profit.

SHEARING WETHERS IN WINTER BEFORE FATTENING THEM.

This experiment was undertaken with the object of determining the profitableness of the practice of shearing wethers some time before fattening them. On December 12, six wethers were selected that were very similar in fleece and form. They were divided into Lots I and II, the former weighing unshorn 291 lbs. The latter weighing unshorn 282 lbs. On the same day the wethers in Lot I were shorn, but those in Lot II were left unshorn. It was not until January 8th that the writer was able to undertake the experiment. After two weeks of preliminary feeding to accustom the wethers to the foods making their rations, the experiment began February 2, under favorable conditions. The unshorn wethers in Lot I weighed a total of 302 lbs., and the shorn wethers of Lot II weighed 296 lbs. Both lots were given all they would eat of meadow hay, sugar beets and grain; the latter consisting of one part oil meal, one part of oats and four parts

whole corn by weight. The following table will show the amounts of these foods that each ate and the gain made during the periods of one week:

Table showing food eaten and the gain made by shorn and unshorn wethers.

Week Ending.	Lot I — Shorn. Food Eaten. Hay.	Roots.	Grain.	Weekly Gain.	Lot II — Unshorn. Food Eaten. Hay.	Roots.	Grain.	Weekly Gain.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
February 9	20	28	41	11	14.5	27	39	13
February 16	18.5	28	41	7	17	28	41	15
February 23	20	28	43	3	19	28	43	3
March 2	19.5	28	48	12	21.5	27	48	13
March 9	20.5	28	48	12	22	28	48	10
March 16	25.2	28	52	11	27.5	28	52	9
March 23	24	28	52	17	20.5	28	53	21
March 30	22	27	58	13	23	27	54.5	6
April 6	21.2	28	60	14	24.5	28	58	16
April 13	21.2	28	60	13	25.2	28	60	11
April 20	19.5	28	56.5	7	22	28	50.5	10
11 weeks	231.6	307	559.5	120	236.7	305	547	127

In fixing the cost of these rations, the same scale of prices is used that is given in the experiment with feeding fodders to breeding ewes. At the rate there given, Lot I that was shorn made a gain of 120 lbs. during eleven weeks at a total cost of $5.64 or at the rate of $4.70 per one hundred pounds gain. During the same time Lot II, left unshorn, made 127 lbs. gain at a total cost of $5.55 or at the rate of $4.40 per one hundred pounds gain. From these figures it will be seen that Lot II left unshorn not only made a greater total gain than the shorn wethers of Lot I, but also made a cheaper gain. It remains to be said that the temperature of the sheep shed in which these wethers were fed had no doubt some influence on the results of the experiment. The shed is a light wooden structure with single-boarded walls built

with the main idea of securing the most healthful conditions for the sheep that are in it and for that reason good ventilation was considered of more importance than undue warmth. The average temperature of the shed during the period of experiment was about 35° Fahr.

As the wethers were of similar breeding and much alike in fleece and type the conditions are favorable for a close separation of the facts relating to the influence of this practice upon the growth of wool from those that bear upon the production of flesh. Both lots being very even and both receiving the same food, it is clear that the differences originating during the time of experiment are due to the practice of shearing before fattening.

EFFECTS ON THE GROWTH OF WOOL.

At the first shearing December 12th, Lot I yielded a total of 16.4 lbs. and at the second shearing on April 24th, they again clipped 12.1 lbs., making a total yield of 28.5 lbs. unwashed wool. Lot II, shorn April 24th, on the conclusion of the experiment, gave a total clip of 32.7 lbs. unwashed wool, or 4.2 lbs. more than Lot I. Taking the average of the first clip of Lot I, as that of Lot II had they been shorn at that time, we thus find that during the period of experiment, Lot I yielded in wool an increase of 12.1 lbs. and Lot II, 16.3 lbs. unwashed wool. The fleeces were tub washed in water at a temperature of 76° Fahr., with the object of finding out the extent to which the yolk contributed to the weights of the different fleeces. The fleeces of Lot I, taken from the sheep in two clippings, lost in the washing 36 per cent., while that of Lot II, the result of one shearing, loss 44 per cent., showing that the fleeces of Lot II contained 8 per cent. more yolk than that of Lot I. It should not be overlooked that the wool from Lot II would suit the market better than that from Lot I, owing to the fact that the latter was much shorter in staple.

EFFECTS ON THE INCREASE OF FLESH.

By taking the increase of wool made by each lot from the total gain made by each during the period, we can de-

termine the proportion of gain that is due to the increase of flesh. In this way we find that the shorn wethers of Lot I made a gain in flesh of 107.9 lbs., while the unshorn wethers of Lot II gained 110.7 lbs.; being a difference of 2.7 lbs. in favor of Lot II. The mutton from these lots was very uniform in the proportion of fat and lean, there being an even mixture in all instances. The carcasses were dressed and the weight of the blood, heart, liver, lungs, kidneys, skin, spleen and length of the large and small intestines as well as fat surrounding these, were carefully noted but no material difference was found between the two lots. In the following table these results are given:

Tables giving the results of slaughtering shorn and unshorn wether lambs.

Lot I. Shorn.

No.	Weight before killing.	Dressed weight.	Per cent. shrinkage.	Blood.	Caul fat.	Gut fat.	Heart.	Liver.	Lungs.	Skin.	Length of small intestines.		Length of large intestines.		Kidneys.	Stomach.	Spleen.
	Lbs.	Lbs.		Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Ft.	In.	Ft.	In.	Lbs	Lbs	Lbs
348.........	154	81¾	46	6	6.8	1.8	.5	2.1	2.2	10.6	87	..	15	11	.2	3.8	.1
354.........	130	67¼	49	5.1	4.7	1.6	.3	2	2	9.3	79	5	17	..	.2	3.4	.2
353....	132	71	46	3.6	4.9	2	.5	1.7	2.1	9.2	83	..	23	5	.2	3.3	.2
Average.	138.6	73.3	47	4.9	5.3	1.8	.4	1.9	2.1	9.7	83	2	18	9	.2	3.5	.2

Lot II. Unshorn.

No.	Weight before killing.	Dressed weight.	Per cent. shrinkage.	Blood.	Caul fat.	Gut fat.	Heart.	Liver.	Lungs.	Skin.	Length of small intestines.		Length of large intestines.		Kidneys.	Stomach.	Spleen.
	Lbs.	Lbs.		Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	Ft.	In.	Ft.	In.	Lbs	Lbs	Lbs
351....... .	116	60	48	3.8	3.7	1.5	.5	2	2	9.2	82	..	17	..	.2	3.3	.1
352...	138	75.5	45	5.7	5.5	2.2	.5	2.2	1.9	9.8	81	..	22	.	.3	3.5	.2
358.........	124	66.2	46	3.7	6	2.1	.5	2	1.6	9.3	86	6	20	..	.2	3	.2
Average.	126	67.2	46	4.4	5.1	1.9	.5	2.1	1.8	9.4	83	2	19	6	.2	3.2	.2

As the results of this single trial it appears:

1. When fed in common sheep sheds of an average temperature of 35° Fahr., it is not advisable to shear fattening wethers in December.

2. The wethers left unshorn gave in this trial the greater gain in wool and mutton combined at the least cost.

3. The unshorn wethers yielded the greater weight of,

wool, and that also of a more marketable length of staple, though it contained slightly more yolk.

4. The unshorn wethers made the greater gain in flesh, and in addition the mutton did not differ in its proportions of fat and lean from that of the shorn lot.

FEEDING GRAIN TO LAMBS BEFORE WEANING THEM.

Does it pay to feed grain to lambs while they are running with their dams on good pasture, and obtaining an abundant supply of milk from them? If so, is it better to feed it to the lambs direct or to them through the ewes? To collect such facts as would enable us to answer these questions, we selected nine high grade Shropshire ewes that had nine lambs at foot. The ewes being uniform and the lambs similar in type and quality, having been sired by the same ram, it was an easy matter to divide them into three even lots. In the instance of Lot I the lambs received all they would eat of a mixture of 1 part corn meal, 1 part bran and $\frac{1}{4}$ part of oil meal, all by weight. To the ewes of Lot II we fed the same grain mixture as to the lambs of Lot I. They were restricted in quantity, so that during the period of experiment they would consume no more than the lambs did. The ewes and lambs in Lot III received nothing but good pasture. All the lots were kept on pasture of similar character, and during the whole period, with the exception of a short time spent in striving to determine the differences in the amounts of pasturage consumed, they were together. Owing to spells of rainy weather the ewes and lambs had to be sheltered at times in the shed. During these short periods, they were fed all they would eat of roots, corn fodder and hay; the amounts of which were carefully noted and charged against each lot. The lambs of Lot I were fed grain night and morning in the shed. By means of a light open partition that would permit the lambs to pass through, but not the ewes, it was easy to feed the lambs of Lot I all the grain they would eat. The effects of these different systems of management on the lambs will be seen in the following tables:

Table showing weight of ewes and gain of lambs.

Lot I. Ewes pasture; lambs fed grain.

Date.	Weight of Ewes. No. 1220.	Weight of Ewes. No. 1229.	Weight of Ewes. No. 1213.	Total weekly gain (†) or Loss (—).	Weight of Lambs. No. 307. Lambed March 28. Dam No. 1220.	Weight of Lambs. No. 376 Lambed April 18. Dam No. 1229.	Weight of Lambs. No. 371. Lambed April 17. Dam No. 1213,	Total weekly gain.
	Lbs.	Lbs	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
April 30	109	131	118	....	23.50	16.00	16.5	....
May 7....	109	131	121	† 3	29.00	20.00	22.0	15
May 14.....	110	132	116	— 3	32.25	24.75	27.0	13
May 21..........	108	133	118	† 1	37.00	30.50	33.50	17
May 28..........	111	137	118	† 7	41.00	34.50	38.5	13
June 4..........	107	129	117	—13	44.75	39.50	43.5	13.75
June 11..........	107	124	115	— 7	45 50	41.50	46.5	5.75
June 18	108	130	121	†13	51.50	47.25	54	19.25
June 25...	108	134	121	† 4	56.50	52	59	14.75
July 2.....	115	132	120	† 4	60	57	62.5	12
July 9	104	129	117	—17	64	60	66.5	11
10 weeks.....	......	......	.....	— 8	Gain 40.5	Gain 50.	Gain 50.	134 5
Ewes during period lost 8 lbs.					Average weekly gain of each lamb, 4.48 lbs.			

† Plus.

Lot II. Ewes pasture and grain; lambs no grain.

DATE.	WEIGHT OF EWES. No. 1225.	No. 1222.	No. 1226.	Total weekly gain (†) or loss (—)	WEIGHT OF LAMBS. No. 364. Lambed March 21, Dam No. 1225	No. 374. Lambed April 22. Dam No. 1222	No. 377. Lambed April 19. Dam No. 1226	Total weekly gain.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
April 30	132	150	128	....	33.5	14.75	14	....
May 7	137	152	131	†10	39	20	19.5	16.25
May 14	140	145	129	— 6	43.5	25	24	14
May 21	138	148	132	† 4	47.25	27.5	28.5	10.75
May 28	143	158	134	†17	50.25	29.5	31.5	8
June 4	139	154	133	— 9	56.75	29.5	35	10
June 11	136	*	127	— 6	58.75	(died)	38	5
June 18	140	......	132	† 9	64	....	41.5	8.75
June 25	144	.....	135	† 7	68	....	48	10.50
July 2	146	......	134	† 1	73	....	51.5	8.50
July 9	148	......	132	....	75	....	55	5.50
10 weeks	......	......	.....	†27	Gain 41.5	Gain 14.75	Gain 41	97.25
Ewes during period gained 27 lbs.					Average weekly gain of each lamb, 3.87 lbs.			

* This ewe was taken out of this lot as her lamb died.

† Plus.

Lot III. Ewes pasture; lambs no grain.

Date.	Weight of Ewes.			Total weekly gain (†) or loss (–).	Weight of Lambs.			Total weekly gain.
	No. 1216.	No. 1215.	No. 1227.		No. 369. Lambed March 28. Dam No. 1216.	No. 367. Lambed March 24. Dam No. 1215.	No. 375. Lambed April 25. Dam No. 1227.	
	Lbs.	Lbs	Lbs	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
April 30..........	129	119	119	....	23.00	21.50	13.50	......
May 7............	133	122	119	† 7	26.00	25.50	17.50	11.00
May 14...........	129	122	129	† 6	29.25	30.00	22 00	12.25
May 21......	134	124	128	† 6	31.50	32.00	25.50	7.75
May 28....... ...	137	129	130	†10	37.50	36.00	29.00	13.50
June 4......	134	124	128	–10	41 50	40.00	34.00	13.00
June 11..	130	122	125	– 9	44.00	40 00	35.50	4.00
June 18..........	131	124	128	† 6	49.25	43.50	40.00	13.25
June 25....	134	124	127	† 2	53.00	48.00	44.00	12.25
July 2...	131	121	120	–13	58.50	52.00	48 50	14.00
July 9....	126	121	117	– 8	61.50	54.00	52.00	8.50
10 weeks				– 3	Gain 38 50	Gain 32 50	Gain 38.50	109.50
Ewes during period lost 3 lbs.					Average weekly gain of each lamb 3.65 lbs.			

† Plus.

As would be expected the foregoing tables indicate that the younger the lamb the greater is the gain. Moreover, it will be made clear by dividing the term of experiment into two periods of five weeks, that Lot I made its best gain compared with Lot III the first period of the experiment. During that time Lot 1 made a gain of 71.75 lbs., while Lot III made a gain of 57.50 lbs. during the same period. In the second period of five weeks Lot I made a gain of 62.75 lbs., while Lot III gained 52 lbs. The difference of gain in the first period is 14.25 lbs. in favor of Lot I, which gain we may credit to the 18.75 lbs. of grain mixture they ate during that time. In the second period the difference in gain between these lots is only 10.75 lbs. in favor of Lot I, due to the 61.25 lbs. of grain they consumed during that period. With these facts in mind it is clear that the best results are derived from feeding grain to lambs as soon as they will relish it, which is usually when they are from two to three weeks old.

Table showing food consumed.

DATE.	LOT I.—EWES PASTURE; LAMBS GRAIN.				LOT II.—EWES PASTURE AND GRAIN; LAMBS NO GRAIN.				LOT III.—EWES PASTURE; LAMBS NO GRAIN.		
	Ewes.			*Lambs.*	*Ewes.*				*Ewes.*		
	Corn fodder.	Roots	Hay	Grain	Corn fodder.	Roots	Hay.	Grain	Corn fodder	Roots	Hay.
Week ending	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
May 7......	31.5	84	......	.50	27	84	.....	21.5	19.50	84	.....
May 14......	38.0	30	......	4.25	39	30	......	8.5	36.00	30	.....
May 21......	......	......	16.5	1.75	......	......	15	7.0	......	......	16.25
May 28......	......	......	14.5	5.50	......	......	16.75	3.5	......	......	17.C0
June 4......	......	......	......	6.75	......	......	......	3.5	......	......	......
June 11......	......	......	......	9.00	......	......	......	3.0	......	......	......
June 28......	......	......	......	14.00	......	......	......	2.0	......	......	......
June 25......	......	......	......	14.50	......	......	......	6.0	......	......	......
July 2......	......	......	......	9.75	......	......	......	11.0	......	......	......
July 9......	......	......	......	14.00	......	......	......	14.00	......	......	......
Total eaten	69.5	114	31.0	80.00	66	114	31.75	80.00	55.£0	114	33.25

COMPARATIVE COST OF GAIN.

To determine the comparative cost of gain we use the same scale of prices that is given in the first of the sheep experiments described in this report. We find that in Lot I the ewes ate, besides the pasturage they received, 69.5 lbs. cut corn fodder, 114 lbs. roots and 31 lbs. of hay and the lambs of the same lot ate 80 lbs. of grain, amounting in cost to a total of 91 cts. In Lot II, additional to the pasturage, the ewes ate 66 lbs. cut corn fodder, 114 lbs. roots, 31.74 lbs. hay and 80 lbs. of grain, costing in all, 91 cts. In Lot III the ewes ate, besides their pasturage, 55.50 lbs. cut corn fodder, 114 lbs. roots and 33.25 lbs. hay, the total cost of which is 35 cts.

From the preceding tables it will be seen that Lot I in which the lambs were fed grain, made 25 lbs. gain more than Lot III, in which neither the ewes nor the lambs were given any grain. This excess of 25 lbs. gain was made at a comparative cost of 56 cents. These figures make it evident that it pays to feed such grain as we fed in this experiment to lambs before weaning them. Owing to the death of one of the lambs in Lot II, the figures for that lot can only be used in averages. We find that the lambs in Lot II, however, did not make as high an average weekly gain as those in Lot I, but yet they did much better than those in Lot III. We must credit Lot II with the gain made by the ewes during the period. They gained 27 lbs. while the ewes of Lot I lost 8 lbs. and those of Lot III lost 3 lbs. It may be, and it is quite probable, that the best results would accrue from a combination of the methods of feeding Lots I and II; that is, to feed both the ewes and lambs grain.

While the excess gain of 25 lbs. at the low cost of 56 cents is ample evidence of the advisability of following the practice of grain feeding lambs before weaning them, yet there are other good features associated with the practice that deserve mention. The lambs that received grain could be tided over the weaning period unchecked in their growth. They would mature earlier than the others and they could be marketed earlier if it were an advantage to

do so. It was easy during the course of the experiment to single out the grain fed lambs because of their plumper and smoother appearance, which we accepted as the external evidences of well nourished bodies and sound, even wool.

Our conclusions drawn from this experiment are:

1. It is good management to feed the lambs before weaning them, all they will eat of such grain mixtures as that used in this experiment. The lot of three lambs so fed, made an excess gain over the the lot receiving no grain of 25 lbs. during ten weeks at a cost of 56 cents.

2. To fed the ewes the grain mixture instead of the lambs is not likely to give as good results as feeding it to the lambs direct, though it does seem that a combination of both practices would be the best.

3. To make the cheapest and the greatest gain for each pound of grain consumed, the lambs should be taught to eat grain as early in life as possible.

NOTES ON CROSS BREEDING SHEEP; THE RESULTS OF CROSSING THE SHROPSHIRE DOWN WITH THE AMERICAN MERINO.

With sheep breeding in its present condition of development in Wisconsin, there is considerable importance attached to the question of crossing fine wooled ewes with rams of the mutton breeds for the purpose of cheaply establishing and grading up a flock of ewes for breeding mutton sheep. An active interest in mutton production has arisen having its origin in a demand that at present is strong and promising. Many farmers find that under these conditions they could breed mutton sheep with much profit, but their flock includes only fine wooled ewes. A vital matter confronts them in the question of how to change most cheaply and advantageously from the growing of fine wool to the rearing of mutton sheep. Bearing on this question and that also of cross-breeding, we wish to present a few notes that have originated in our flock. We do not record this as an experiment, for we have tried only one of the mutton

breeds in this way, but we submit these notes simply to assure others of what can be done in establishing a breeding flock of mutton sheep on a fine wool foundation.

In this work we have tried only the Shropshire and the Merino. The Merino ewes that were bred to Shropshire rams were reared in Walworth county of this state. They were large and good specimens of the fine wooled American Merino. In form and fleece they were representative types of the Merino that has been bred with the sole object of producing fine wool of superior quality in the greatest quantity. The Shropshire rams that were used on these ewes were pure bred. They were good individuals, thoroughly representative of the breed, but in no way sheep of extraordinary development. The first of this work was done in 1889. Since then the best ewe lambs resulting from this cross have been selected for breeding purposes. Last winter we had in our flock twelve two-year-old, first cross Shropshire-Merino ewes. As soon as their lambs were weaned from them six of the worst of these lambs were sold. We have now six of the best of these two-year-old first cross Shropshire-Merino ewes, and three first cross ewe lambs that were selected from the lambs dropped this year out of the same original Merino ewes. We have also five second cross ewe lambs from a Shropshire ram and out of the first cross two-year-old ewes. The rest of the cross bred lambs, which were mostly wethers, have been sold. The results of the work up to date will enable us to make a fair estimate of the worth of this cross.

The best of the first cross Shropshire-Merino ewes possessed many qualities that fit them for the conditions of Wisconsin. The six we have in our flock at present average 140 lbs. in weight. The best six of the Merinos from which the first cross ewes were bred averaged 120 lbs. These are their weights in fair breeding condition. The first cross ewes we have kept do not show much of the flat side, slight quartered and narrowness of the Merino, but they all have the drooping rump of that breed and only three are completely free from folds or wrinkles. They are strong legged, compactly built, medium sized sheep that do well

under common conditions. The best of them have qualities that vouch for their vigor and thrift under the conditions of Wisconsin. In addition they appear to have the herding and social disposition of the Merino. While there has been a material gain in the form of these sheep over that of the Merino for mutton breeding, there has been an additional gain in the wool clipped; for that from the first cross used brought us a higher price in the Chicago market than that of either our Merinos or Shropshires. The crossing did not result in a decreased clip for the increased size of the first cross ewes and the greater length of their wool brought the weight of the latter up to to that of the Merinos. The average clip of twelve of the first cross Shropshire-Merino ewes shorn the fore part of May, was 8.9 lbs., while that of the twelve Merinos shorn the same time was 8.7 lbs. To determine if there was any difference in the amount of yolk or oil in the fleeces of the Merinos and those of the first crosses, we selected one from each and tub washed them in warm water at a temperature of 76° Fahrenheit. The fleeces before washing each weighed 8.4 lbs. After washing and being thoroughly dried, the fleeces of the Merino ewe weighed 5.5 lbs., and that of the first cross 5.6 lbs., which is practically a difference that may be overlooked.

The most striking peculiarities of the fleece of the first cross ewes are its wonderful evenness and density. Their fleeces have at all times the appearance of having been recently trimmed. They are not open or drooping. This is due to the density of the fleece and in a slight degree to the strength of the fiber. In length the wool will average about two and one-half to three inches. It is of medium fineness with the characteristic softness of Merino wool and the brightness of the wool of the Shropshire. The best of the first cross ewes are covered with wool of a uniform quality. A number of them were hairy on the thighs, but that was directly inherited from one of the rams that was very noticeably so. A very favorable feature of the fleece of the first cross ewes is that it protects the sheep in the best possible manner.

The first cross wethers made fairly good sheep for fattening. They cannot be fattened to such heavy weights as the wethers of the mutton breeds nor do they fatten as readily. The second cross wethers, that is, those out of the first cross ewes and by a Shropshire ram, would make much better feeding sheep. As those of this cross that we have mostly kept have been ewe lambs we cannot offer any definite statements as to the fattening qualities of the cross bred wethers.

The second cross ewe lambs now in our flock that were dropped this spring approached more nearly to the Shropshire type. They are an advance on the first cross in size and squareness of form but their fleeces are coarser, longer and more open. They lose the remarkably even and dense fleece of the first cross, while they gain in form and weight.

This work has placed before us a few facts that are at least of importance to the farmer who wishes to found a flock, if not interesting to the breeder. From the results obtained, it seems reasonable to expect that with three, or at most four, top crosses of such a breed as the Shropshire upon even such an extremely different type as the Merino, offspring would result that could not practically be distinguished from the pure-bred Shropshire. The time it will take to reach that degree of development will depend to a considerable extent on the impressive power of the rams that are used. By observing the results of using the rams employed in this work on the other ewes of our flock, we are satisfied that they did not possess more than common impressive powers. Yet, we have lambs, with only two top crosses of the Shropshire on Merinos, that are not easily distinguished from others of pure Shropshire breeding. The importance of this to the farmer lies in the fact that by purchasing a pure-bred mutton ram of ordinary constitutional vigor he may hope to establish in four years a flock of high-graded mutton sheep that will approach near to the best type of any of the mutton breeds.

Some students of breeding have found a fertile line of thought in the statement that the sire imparts the external characteristics to the progeny, and the dam the internal.

There are a few reasons for accepting this theory when applied to the breeding of horses, but we have not met with any facts justifying its application to sheep breeding. We do not wish to base a refutation of the theory on our extremely limited work, but only desire to lay the facts before our readers as we have found them. In cross-breeding the Shropshire and Merino in conformance with the foregoing theory, we should have used a Merino ram on Shropshire ewes with the expectation of getting a Merino fleece on a Shropshire form. A condition, however, forced us to do the reverse, and the results have supported the fallacy of the theory as applied to sheep. The first cross in nearly all respects shows a even mixture of the breed qualities of the Shropshire and Merino. The wool is finer than the Shropshire; it is also denser and shorter. It is longer than the Merino and somewhat coarser and stronger. In appearance the ewes also show the blending of the qualities of both breeds very nicely. The faces of the first cross used are light brown, somewhat speckled in some instances. Their ears have the slight droop and forward pitch of the Merino. The form of their bodies is a merging of the characteristics of both breeds. They are smoother and plumper than the Merino yet not so full bodied as the Shropshire. The gait of many of the ewes is more like that of the Merino; the step is decided and extended. In nearly every instance the peculiar features of such breed used in the crossing have been merged in the first cross sheep. Though these facts may not have the force to overthrow this theory, in its application to the breeding of other animals, they nevertheless point to the falsity of it in sheep breeding. Furthermore they admonish us not to honor a theory because of its age and its general unchallenged acceptance.

THE FEEDING VALUE OF WHEY.

W. A. HENRY.

The experiments here reported were conducted during the fall and winter of 1890-91. We regard them as the beginning only of an extended series of trials in this direction. The results are given to our dairymen and cheese factorymen for the purpose of calling attention to a much despised and often a greatly abused by-product.

One hundred pounds of average milk contain about 13 parts of solids. In the process of butter-making most of the fat is removed by skimming, leaving nearly all of the other solids. In cheese-making the casein is coagulated by rennet, so that nearly all of it is recovered. Most of the fat goes with the casein also. The albumen, a valuable food product, is not coagulated by the rennet, but remains in the whey, as does most of the ash. The following shows the constituents of milk recovered and remaining with the whey, skim milk and buttermilk in the processes of butter and cheese-making:

	Casein.	Albumen.	Fat.	Sugar.	Ash.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
100 pounds of average full milk contain about....	3.5	.7	3.5	4.5	.7
In the process of butter making the skim milk and butter milk together from the above 100 lbs. would contain about......	3.4	.7	.3	4.4	.7
In the process of cheese-making the whey from the above 100 lbs. would contain about..........	.1	.7	.4	4.3	.6

There will be about 90 pounds of whey remaining from the 100 pounds of full milk, 10 pounds of milk constituents

going into the cheese. The figures here given for whey should therefore be increased by one-ninth of the amounts stated in each case, in order to show the constituents in 100 pounds of whey. That whey is nearly all water need not be denied; on the other hand, it should be borne in mind that the casein, albumen, fat, sugar and ash which it does contain, are almost perfectly digestible, and, so far as they go, have a very high nutritive value. The question is not whether whey is worth producing, but rather since it is a necessary and constant by-product in the manufacture of cheese, what is its value, is it worth utilizing, and how can it best be fed?

In the feeding trials with whey here reported, the pigs in all cases were fed at least one week before the experiments proper began, upon the same feed as they received during the trials. This was done in order to accustom the animals to their diet, and also to check errors of light or heavy weights consequent on change of feed. In each trial one lot of pigs received grain only. This consisted in one instance of corn meal and shorts, half and half; in the others, of two-thirds shorts to one-third corn meal. Three pounds of water were mixed with each pound of the grain ration to form a slop; in the other cases, whey in varying proportions was fed mixed with the meal to form a slop. *In all cases the whey was fed sweet.* The amount of feed and the gain made are reported weekly during the trials.

FIRST TRIAL.

The first trial with feeding whey began November 17, 1890. The pigs, numbered 117, 178, 179, 180, 181, 182, 183, 185, were born June 4, 1890, making them about five and one-half months old at the beginning of the trial. Pigs, numbered 190, 191, 192, 193, were born June 16, 1890, and were five months old when the trial began.

For the first two weeks of the trial corn meal was the only grain fed, but after that time the feed consisted of half corn meal and half shorts. At first Lot IV was fed whey only, but the animals scoured so badly that we were

forced to add some day food, which we did by mixing sufficient shorts with the whey to make a thin slop.

The proportions of meal to whey, as near as we could feed them, were as follows:

Lot I, shorts mixed with water.

Lot II, 2 lbs. whey to 1 lb. of the corn meal and shorts mixture.

Lot III, 7 lbs. whey to 1 lb. of the corn meal and shorts mixture.

Lot IV, 10 lbs. whey to 1 lb. of shorts.

The following table shows the gain of each pig of the four lots, and the feed consumed:

Table showing feed consumed and gain of pigs on the first whey experiment.

LOT I.—Fed Corn Meal and Shorts, with Water.					LOT II.—Fed 1 lb. of Corn Meal and Shorts to about 2 of Whey.				
	Weight of Animals.			Feed consumed	Weight of Animals.			Feed consumed.	
Ear tag.	178	181	193	Corn meal and shorts.	180	182	191	Corn meal and shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Nov. 17.	135	132	113	....	150	122	123	....	. ....
24.	143	142	119	108	159	131	122	100	207
Dec. 1.	158	144	129	113	180	148	139	111	210
8.	153	148	125	81	178	153	143	95	210
15.	160	157	132	77	190	164	152	90	210
22.	172	171	142	107	208	173	168	108	221
Net gain	37	39	29	....	58	51	45	....	....

	LOT III.—Fed 1 lb. of Corn Meal and Shorts to about 7 of Whey.					LOT IV.—Fed 1 lb. of Shorts to about 10 of Whey.				
	Weight of Animals			Feed consumed.		Weight of Animals			Feed consumed.	
Ear tag.	177	183	190	Corn meal and shorts.	Whey.	179	185	192	Shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Nov. 17	149	110	133	....	....	140	96	117	....	....
24	152	113	140	64	422	142	97	115	....	634
Dec. 1	165	125	155	59	420	149	101	120	....	630
8	167	128	159	56	420	158	110	132	50	343
15	177	135	170	58.5	420	167	116	143	73.5	283
22	189	136	184	63	442	182	128	162	92	336
Net gain	40	26	51	....	....	42	32	45	....	....

SECOND TRIAL.

The hogs were the same as those in the previous trial; consequently they were between eight and nine months old at the beginning of the experiment, February 23rd, 1891. The lots used in the previous experiment were broken up, forming new groups for this trial. The corn meal and shorts mixture consisted of one part corn meal with two parts shorts, by weight. The proportions of meal to whey, as near as we could feed them, were as follows:

Lot I, corn meal and shorts, with water.

Lot II, 3 lbs. whey to 1 of corn meal and shorts.

Lot III, 6 lbs. whey to 1 of corn meal and shorts.

Lot IV, 10 lbs. whey to 1 of corn meal and shorts.

Table showing feed consumed, and gain of pigs on the second whey experiment.

	LOT I.—Fed Corn Meal and Shorts with Water.				LOT II.—Fed 1 lb. of Corn Meal and Shorts to 3 of Whey.				
	Weight of Animals.			Feed consumed.	Weight of Animals.			Feed consumed.	
Ear tag.	180	190	191	Corn meal and shorts.	178	179	182	Corn meal and shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Feb. 23	238	265	230	....	237	258	240	....	....
March 2	248	269	235	116.5	250	270	250	116 5	330
9	253	273	241	119	252	285	260	119	358
16	259	282	246	126	270	295	270	126	370
23	268	285	255	133	230	310	278	133	399
30	278	295	261	133	280	330	286	133	399
Net gain	40	30	31	....	43	72	46	....	....

	LOT III.—Fed 1 lb. of Corn Meal and Shorts to 6 of Whey.					LOT IV.—Fed 1 lb. of Corn Meal and Shorts to 10 of Whey.				
	Weight of Animals.			Feed consumed.		Weight of Animals.			Feed consumed.	
Ear tag	180	183	193	Corn meal and shorts.	Whey.	74	185	192	Corn meal and shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs	Lbs.	Lbs.
Feb. 23	285	215	210	....	....	290	178	240	....	....
Mar. 2	285	225	220	84	474	305	182	255	60.5	605
9	300	226	228	84	504	304	186	261	63	
16	308	239	238	91	534	315	196	273	70	684
23	317	247	248	98	588	325	200	286	77	770
30	328	250	256	96	576	335	208	297	77	770
Net gain	43	35	46	....	.... .	45	30	57	....	....

THIRD TRIAL.

The pigs used in this trial were about 6 months old and were purchased from a neighboring farm. They were fine animals, showing good breeding, the stock being Poland China, with the last sire a registered Berkshire. Previous

to this trial they had been on an experiment in which they were fed corn meal and skim milk. In this trial the grain feed consisted of two parts shorts or middlings and one part corn meal. They were fed as near as possible, whey, corn meal and shorts in the following proportions:

Lot I, corn meal and shorts, mixed with water.

Lot II, 3 lbs. whey to one of the corn meal and shorts mixture.

Lot III, 6 lbs whey to one of the corn meal and shorts mixture.

Lot IV, 10 lbs. whey to one of the corn meal and shorts mixture.

After the close of the experiment it was found that pigs Nos. 118, 121, 125 and 130 were pregnant, which fact was not known when we purchased them. As there was one of these sows in each lot and as the weights and gains of each animal are reported separately, we have thought best to include them in the results here given. The following table shows the gain of each pig in the four lots, and the feed consumed:

Table showing feed consumed, and gain of pigs on the third whey experiment.

	Lot I.—Fed Corn Meal and Shorts, with Water.					Lot II.—Fed 1 lb. of Corn Meal and Shorts to 3 of Whey.					
	Weight of Animals.				Feed consumed.	Weight of Animals.				Feed consumed.	
Ear tag.	127	129	130	131	Corn meal and shorts.	124	125	128	133	Corn meal and shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Feb. 23	146	150	128	120	....	158	162	124	124	....	....
Mch. 2	152	159	135	126	116.5	170	170	135	135	116.5	330
9	157	164	139	132	119	177	174	142	139	119	358
16	164	173	150	139	126	189	183	148	147	126	370
23	170	183	155	144	133	200	193	153	153	133	399
30	176	188	163	147	138	215	202	161	160	138	414
Net gain	30	38	35	27	....	57	40	37	36	... .	. .. ...

	LOT III.—Fed 1 lb. of Corn Meal and Shorts to 6 of Whey.						LOT IV.—Fed 1 lb. of Corn Meal and Shorts to 10 of Whey.					
	Weight of Animals.				Feed consumed		Weight of Animals.				Feed consum'd	
Ear tag	118	119	120	132	Corn meal and shorts.	Wh'y	117	121	122	126	Corn mealand shorts.	Wh'y
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Feb. 23	145	138	165	130	....	......	147	158	130	120	... .	......
Mch. 2	152	150	175	135	84	474	151	170	139	135	60.5	605
9	157	158	177	137	84	532	154	176	142	141	63	630
16	169	168	189	143	91	534	163	187	149	149	70	684
23	180	173	198	151	98	588	170	197	156	158	77	770
30	192	177	207	159	97	582	176	208	160	163	82	820
Net gain.	47	39	42	29	....	......	29	50	30	43	....	......

FOURTH TRIAL.

The pigs used in this experiment were high grade Poland Chinas. They were born May 25th, 1890, making them a little past nine months old at the beginning of the trial, March 2nd, 1891. The meal fed in this trial consisted of one-half corn meal and one-half shorts, by weight.

Lot I was fed a mixture of meal with water to form a slop.

Lot II was fed 6 lbs. of whey to 1 lb. of the meal mixture.

The following table gives the results:

Table showing feed consumed, and gain of pigs on the fourth whey experiment.

	LOT I.—FED CORN MEAL, SHORTS AND WATER.				LOT. II.—FED 1 LB. OF CORN MEAL AND SHORTS TO 6 OF WHEY.				
	Weight of Animals.			Feed consumed.	Weight of Animals.			Feed consumed.	
Ear tag.	57	162	164	Corn meal and shorts.	56	167	184	Corn meal and shorts.	Whey.
Date.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
March 2	345	310	303	....	330	327	325	....	....
9	355	320	310	125.5	338	340	332	90.5	543
16	367	323	320	137.5	348	351	338	98	578
23	373	334	325	140	350	363	343	98	588
30	373	340	330	140	360	376	357	98	588
Net gain..	28	30	27	....	30	49	32	....	....

From these four tables we deduce the following, which shows the results of the four trials in a condensed form:

Table showing weight of pigs, amount of feed consumed, the gain and the amount of whey required to save 100 pounds of meal.

	Feed consumed.		Total gain.	Feed for 100 lbs. gain.		Meal saved by whey.	**Whey for 100 lbs. meal.**
First trial — Average weight of animals 127 pounds.	Meal.	Whey.		Meal.	Whey.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	**Lbs.**
Lot I	486	....	105	463	....	....	....
II	504	1,058	154	327	687	136	**505**
III	300.5	2,124	117	257	1,815	206	**881**
IV	215.5	2,226	119	181	1,871	282	**663**
Second trial — Average wt. of animals 240 pounds.							
Lot I	627.5	....	101	621	....	....	....
II	627.5	1,856	161	390	1,153	231	**499**
III	453	2,676	124	365	2,158	256	**843**
IV	347.5	3,159	132	263	2,620	358	**732**
Third trial — Average weight of animals 140 pounds.							
Lot I	632.5	....	130	486	....	....	....
II	632.5	1,871	170	372	1,100	114	**964**
III	454	2,710	157	289	1,726	197	**876**
IV	352.5	3,509	152	232	2,309	254	**909**
Fourth trial — Average wt. of animals 323 pounds.							
Lot I	543	......	85	639	....	....	....
II	384.5	2,297	111	346	2,069	293	**706**

The table shows that in these four trials one lot of pigs in each trial was fed corn meal with shorts and water. The average of these four trials shows that it required 552 lbs. of the corn meal and shorts mixture to produce 100 lbs. of gain, the extremes being 486 lbs. in the first trial and 632.5 lbs. in the third trial. In the same four trials 10 lots of pigs were fed whey along with the mixture of corn meal and shorts, and in every instance a very considerable amount of the grain mixture was saved by the whey. The last column shows the value of the whey as a partial substitute for the meal and shorts mixture. With Lot II in the sec-

ond trial 499 lbs. of whey proved a substitute for 100 lbs. of the corn meal and shorts mixture. With Lot II in the third trial 964 lbs. of whey were required to produce the same result. The average of the 10 lots shows that 758 lbs. of whey effected a saving of 100 lbs. of the corn meal and shorts mixture by partial substitution. If corn meal and shorts are worth $12 per ton, and if 758 lbs. of whey can be substituted in part for the grain mixture and save one hundred pounds of it, then the whey is worth 8 cents per hundred pounds for that purpose. If we value corn meal and shorts at $15 per ton, then the whey would be worth 10 cents per hundred pounds. Prof. Fjord found* as the result of a large number of very carefully conducted experiments with the whey left in the manufacture of skimmed cheese produced from centrifugal skimmed milk, that 1,200 lbs. of whey equaled 100 lbs. of barley or rye meal as a partial substitute. The whey used by Fjord contained but little more than a trace of fat. His results probably show too low a value for the whey from American cheese factories. On the other hand, it is probable that our results are somewhat too high. In the second and fourth trials the pigs that received grain did not make the gains they should for the feed consumed, hence the average shows too large an amount of corn meal and shorts required for 100 lbs. of gain. Since this average is the basis for the calculations which follow, it is probable that the average of 758 lbs. of whey equaling 100 lbs. of corn meal and shorts is somewhat too high.

It seems reasonable, and the tables seem to show that the whey has increased the availability of the ration by more than the solids added to it in the whey. That is, if the meal mixture has a certain value of itself, and the whey has a certain other value, the combination of the two has a higher value than the sum resulting from adding the value of the whey to the value of the meal. In saying, then, that 758 lbs. of whey or any other amount, equal 100 lbs. of meal, it is implied that it has that value in part because of the combination.

* Fordingsforsoeg med Svin, 1887.

Judging from the composition of whey, it is an incomplete food in itself, leaving out the question of dilution. Its largest constituent is milk sugar, which does not build up the muscular system. From its composition we are led to believe that in feeding whey to growing animals we should furnish them with it a liberal amount of protein. This can be given in shorts, pea meal or oil meal. Some corn or barley meal may be fed at all times, the proportion increasing as the animals go toward maturity.

It should be remembered that our results were obtained with sweet whey in the winter time.

The subject of how to keep whey sweet and in the best condition for feeding, demands and will doubtless receive early attention at this or some other station. Factorymen and farmers who feed whey diluted with the washings from the factory and left in the whey tank until sour or worse, should not expect to approximate the results obtained in our trials, or even those of Fjord.

The results of these trials show:

1st. We were not successful in maintaining pigs on whey alone.

2nd. Pigs fed on corn meal and shorts with water required 552 lbs. of the mixture for 100 lbs. of gain.

3rd. When whey was added to the corn meal and shorts mixture, it produced a marked saving in the amount of grain required for good gains. This was true for mixtures varying from two pounds of whey to one of grain, up to ten pounds of whey to one of grain.

4th. It was found when using whey as a partial substitute for grain, that 758 lbs. of whey effected a saving of 100 lbs. of the corn meal and shorts mixture.

5th. Using these figures, if corn meal and shorts are valued at $12 per ton, then whey is worth 8 cents per hundred pounds; at $15 per ton for the corn meal and shorts, whey would be worth 10 cents per hundred weight.

6th. Shorts, pea meal and oil meal, or like feeds, should be mixed with whey for growing animals. Some corn may be fed at all times, the proportion increasing as the animal approaches maturity.

THE RELATIVE VALUE OF CORN SILAGE AND FIELD CURED FODDER CORN FOR MILK AND BUTTER PRODUCTION.

F. W. WOLL.

A series of feeding experiments has been conducted at this Station during the last seven years for the study of the relative value of siloed and of field cured Indian corn for milk production. The experiments have been described in our previous annual reports; their plan has always been similar in this respect, that only a small number of cows, at most four at a time, were experimented with, and that the feeding periods were short, from three to four weeks. In last season's work, it was decided to conduct no other feeding experiment with our cows than a silage vs. fodder corn experiment, to include all available cows in our herd in the experiment, and to continue the experiment for a sufficiently long time to feed the larger portion at least of the silage from our 80 ton silo.

The silo was filled with B. & W. and Yellow Dent corn grown on a piece of land four and one-third acres large. By feeding the larger quantity of the silage on the experiment against a similar quantity of dry fodder corn, it was thought probable that differences in the feeding value of the two foods might appear that could not be discovered where only comparatively small quantities were fed, as in our previous experiments in this line.

Sixteen of the cows that had come in fresh in the fall were selected for the experiment, and four more were added after a couple of weeks, making the number of cows on the experiment twenty in all.

PLAN OF THE EXPERIMENT.

The experiment was similar in plan to our previous work in this line, in so far as the main portion of the ration fed to the cows was made up of silage or dry fodder corn, and these were fed ad libitum; the cows received the following rations per day during the experiment:

Silage periods.	*Fodder corn periods.*
Corn silage, ad libitum.	Fodder corn, ad libitum.
Hay, 4 lbs.	Hay, 4 lbs.
Wheat bran, 5 lbs.	Wheat bran, 5 lbs.
Wheat Shorts, 2 lbs.	Wheat shorts, 2 lbs.

The experiment proper began December 15, 1890, after a week of preliminary feeding; the first period lasted until February 9th, when the feeds were reversed, and the ten cows having received silage during the first period were fed dry fodder corn during the second period, and vice versa. The week following the first period was not considered as belonging to the experiment proper. The second period lasted from February 16th to April 13th, making the number of days in which the experiment was conducted, 112 in all.

The following is a list of the cows on the experiment, with information as to their breed, age, time of calving and average live weight:

Table giving description of cows on the experiment.

Name of cow.	Breed.	Age.	Date of calving.	Av. live weight.
Bunn	Cross bred Holstein and Jersey	7 yrs.	Sept. 16, 1890	1,109
Jessie	Grade Jersey	10	Sept. 23, 1890	949
Dollie	Grade Jersey	7	Sept. 15, 1890	876
Sylvia	Grade Jersey	9	Sept. 22, 1890	860
Bessie 2d	High grade Jersey	6	Nov. 7, 1890	827
Beauty	Native	10	Dec. 3, 1890	1,038
Topsy	Grade Holstein	10	Sept. 19, 1890	1,061
Rosette	High grade Jersey	3	Dec. 7, 1890	715
Sylvan	High grade Jersey	3	Dec. 20, 1890	628
Queenita	High grade Jersey	3	Dec. 26, 1890	607
Mattie	Grade Holstein	9	Oct. 9, 1890	1,100
Galena	High grade Jersey	7	Oct. 25, 1890	883
Bessie	Grade Jersey	11	Oct. 10, 1890	858
Gay	Grade Jersey	8	Nov. 2, 1790	820
Doubtful	Grade Jersey	6	Jan. 17, 1891	1,032
Roan	Grade Shorthorn	10	Sept. 17, 1890	1,006
Rose	Jersey	9	Sept. 30, 1890	938
Daisy 2d	High grade Jersey	5	Oct. 5, 1890	816
Palmer	High grade Jersey	3	Dec. 15, 1890	681
Daisy	Grade Jersey	9	Dec. 26, 1890	688

The first ten cows of the above list were fed dry fodder corn during the first period, and the rest received silage during the same time.

FODDERS FED.

The fodders fed on the experiment were, B. & W. ensilage and Pride of the North yellow dent corn, blue grass hay, wheat bran, and wheat shorts. The B. & W. and Yellow Dent corn were obtained from a field of an area of $8\frac{2}{3}$ acres. The silage and dry fodder corn were prepared from these varieties of Indian corn in a similar manner as in previous years. The field was a narrow strip of land, about 1,725 feet long, with rows running lengthwise. Fourteen rows of B. & W. corn were planted, and the rest

of the field was planted to Pride of the North corn. In cutting for the silo, two rows were cut, weighed and filled into the silo and the two next rows were cut and shocked in the field for dry fodder. In selecting such long rows and alternating two for the silo and two for shocked corn, it is believed that any unevenness in yield was obliterated, and the weight of green fodder filled into the silo is taken for the weight of corn shocked, as well. The silo was filled September 2d to 9th, about 18 loads being cut and filled into it during each day. The cured fodder corn was left in the field till a little before it was needed on the experiment.

The hay fed was blue grass mixed with a fair quantity of clover and timothy. The wheat bran and shorts were made by the roller process, and bought from local mills.

SAMPLING OF FODDERS.

The dry matter fed to the cows during each week was ascertained by weekly sampling of silage, fodder corn and grain feed. A quart jar full was taken for a sample of silage and fodder corn, the samples being taken as the feed was being weighed out for the cows. A pint jar full was taken for a sample of the grain feed. In all, 17 samples of each feed were taken, and their content of dry matter and protein determined.

CONDUCT OF THE EXPERIMENT.

The cows were fed twice a day, and watered once a day, in the forenoon. They were milked at 5 A. M. and 4:30 P. M., and each milking weighed; every third or fourth week the milk from each cow on the experiment was sampled and analyzed for a period of seven days, separate samples from the evening's and morning's milking of each cow being taken and analyzed for its fat content. This necessiated analysis of forty samples of milk daily, an amount of analytical work made possible only by the adoption of a quick method of fat determination, as for instance the one used, Babcock's test.

Six series of analyses of milk, of a week each, were made in all.

The cows were weighed daily in the forenoon during the weeks when their milk was analyzed, and the water drank by each animal was also weighed. The cows received as much fodder corn or silage as they would eat, but no more, each animal being carefully watched and fed according to its appetite; the total feed eaten at every meal was recorded, and also whatever small refuse there might be. As a rule, the attendant fed very judiciously, so that there was a refuse only in exceptional cases; the silagé was eaten up clean throughout the experiment, and the cows seemed to take it in preference to hay. Half the hay and grain feed was fed in the morning and half at night.

The daily figures of feed eaten, milk given, live weight, and water drunk, as well as the analyses of milk from the 20 cows during the four months of the experiment, fill three record books, and cannot be reproduced here; nor would it serve any particular purpose, but would rather tend to obscure the results obtained. In the following pages only such details are given as are necessary for a full understanding of the conclusions drawn, and as a rule only average figures are presented for the whole experiment, for each cow or the whole herd.

LIVE WEIGHT AND WATER DRANK.

The animals kept up very well in live weight during the whole experiment, so that at the close they weighed on an average more than at the beginning four months earlier. The average weights of the cows while on silage was 28.9 lbs. greater than while on fodder corn, the increase in live weight ranging from 62.5 to 5.6 lbs. All cows but one weighed more when on the succulent ration; the one cow, Daisy Second, weighed on an average 1.1 lb. less while on silage than when on fodder corn, owing to her gain in weight while on fodder corn. There was an average gain per cow of 1.7 lbs. during the first period (December, 1890, to February, 1891,) and an average gain of 16.6 lbs. during the second period. This is independent of the feed, as half the number of cows were fed on silage and half on fodder

corn in either case. Comparing the first set of weighings, made December 15th to 22d, with the last set (April 6th to 13th), we find that the cows gained on an average 11.9 lbs. during the experiment.

The cows drank on an average 23.7 lbs. more water while on fodder corn than when they were on silage. The following short table gives the average figures for live weight and water drank:

	While on silage.	*While on corn fodder*
Average live weight of cows...	854.8 lbs.	825.9 lbs.
Average water drank daily...	52.8 lbs.	76.5 lbs.

The greatest difference in the live weight of any cow while on silage and on fodder corn came with Bunn, which weighed on an average 62.6 lbs. more during the former period; this cow also drank the greatest average quantity of water of any cow, viz.: 99.1 lbs. per day while on fodder corn. Roan drank the greatest quantity of water when the cows were on silage, viz.: 74 lbs.; Queenita drank the least of all the cows, viz.: 60.8 lbs. during the fodder corn period, and 43.3 lbs. during the silage period.

FODDER EATEN.

Besides four pounds of hay and seven pounds of grain feed per head, the cows ate daily on an average 59.3 lbs. of silage, containing 16.29 lbs. of dry matter, and during the dry fodder periods 18.71 lbs. of fodder corn, containing 13.51 lbs. of dry matter. This shows, as has been found in previous work in this line, that cows will eat more when fed silage than when fed fodder corn, when they get all they want in both cases.

In all, 64,643 lbs. of silage were fed out to the twenty cows during the experiment, and 20,394 lbs. of fodder corn, equal to 17,743 lbs., and 14,726 lbs. of dry matter, with silage and fodder corn respectively. 25,143.9 lbs. of dry matter were fed in the dry fodder, hay, and grain feed, consumed on the fodder corn periods, and 28,160.9 lbs. on the silage periods, or 23.08 lbs., and 25.83 lbs. of dry matter per day and per cow during the fodder corn and silage periods respectively. We shall now see what was produced by the cows from this quantity of feed.

QUANTITY OF MILK PRODUCED.

The total milk yield of the cows during the whole experiment is given in the following table:

On silage.		On fodder corn.	
Morning	10,338.2 lbs.	Morning	10,318.5 lbs.
Evening	9,475.2 lbs.	Evening	9,482.7 lbs.
Total	19,813.4 lbs.	Total	19,801.2 lbs
	Difference 12.2 lbs.		

This difference of 12.2 lbs. of milk in favor of the silage feed is of course too minute to have any significance whatever. It amounts to only .06 of one per cent. of the total yield; it is indeed a closer result than could be expected if the animals had been fed on the same feed during the whole experiment.

As regards the production of milk fat, we have data for six weeks for each feed. The total quantity of milk and milk fat produced during this time are given in the following table:

Table showing yield of milk and milk fat.

	On silage.	On fodder corn.
Total milk yield for six weeks	7440.3 lbs.	7255.1 lbs.
Difference in favor of the silage	185.2 lbs.	
Or in per cent.	2.6	
Total fat in milk during six weeks	337.70 lbs.	324.14 lbs.
Difference in favor of silage	13.56 lbs.	
Or in per cent.	4.2	
Average per cent. of fat in milk	4.54	4.47

During the six weeks in which the above quantities of milk and milk fat were produced, the cows ate in all 23,958 lbs. of silage and 7,663 lbs. of fodder corn. They received in all 10,468 lbs. of dry matter in their silage ration and 9,466 lbs. in their fodder corn ration. Calcula-

ting the quantities of milk and milk fat produced by the same quantity of dry matter, for instance by 100 lbs., we have the following data:

100 lbs. of Dry Matter in:—	Milk.	Milk Fat.
Silage ration produced	71.09 lbs.	3.226 lbs.
Fodder corn ration produced	76.63 lbs.	3.424 lbs.
In favor of fodder corn	5.54 lbs.	.198 lb.
Or in per cent	7.8 pct.	6.1 pct.

During the six weeks when milk analyses were made, we notice that the fodder corn ration was somewhat more productive; while, as we learned, the cows ate more dry matter on silage than on fodder corn in these weeks (10.6 per cent. more), and produced more milk and milk fat during these weeks (2.6 pct. and 4.2 pct. respectively), the increase in yield did not come up to increase in fat content, and consequently 100 lbs. of dry matter in the fodder corn ration produced somewhat more than the same quantity in the silage ration. As it is of interest to notice the difference in the productive capacity of individual cows, we give below the average quantity of milk given by each cow during the fodder corn and silage periods, and also the average daily quantity of coarse feed (i. e., silage or fodder corn) eaten during each period:

Table showing average quantity of coarse feed eaten, and of milk produced per day and per cow, in pounds.

NAME OF COW.	ON SILAGE.		ON FODDER CORN.	
	Coarse feed eaten.	Average milk yield.	Coarse feed eaten.	Average milk yield.
Bunn	79.38	21.76	27.76	27.81
Jessie	68.16	15.77	21.91	20.49
Dollie	52.01	8.99	19.21	11.12
Sylvia	62.13	14.93	21.45	15 85
Bessie's Heifer	67.48	19.26	23.10	22.58
Beauty	61.96	18.53	22.65	22.59
Topsy	77.98	17.99	26.89	22.12
Rosette	42 76	13.84	13.03	16.79
Queenita	37 26	11.83	11.54	15.54
Sylvan	33.21	12.33	9.43	14.54
Mattie	77.18	22.88	20.99	19.30
Galena	60.30	24.54	18.13	19.48
Bessie	52.68	18.83	14.06	13.67
Gay	54.40	17 29	15.53	15.92
Doubtful	62.46	13.24	18.59	12.49
Roan	75.34	25 79	18.90	20.17
Rose	55.99	21.64	14.13	17.00
Daisy's Heifer	65.18	20.10	20.45	16.51
Palmer	40.43	21.65	15.35	15.27
Daisy	55.56	27.46	18.51	22.72
Average	59.31	18.18	18.71	18.17

The first ten cows given in the preceding table received fodder corn during Period I (December 15th to February 9th), and silage during Period II (February 16th to April 13th); the average milk yields for these cows are therefore lower during the silage period on account of the more advanced stage in the lactation period. The same applies to the fodder corn period with the last ten cows, which received silage during Period I and fodder corn during Period II. Taking the average for all the cows, the milk yield is very nearly the same, as we have already seen.

When we consider the total quantity of the same food con-

sumed by the twenty cows during the whole experiment, and also the milk produced, we notice that 28,160.9 lbs. of dry matter during the silage period produced practically the same quantity of milk as did the 25,143.9 lbs. of dry matter during the fodder corn periods. Putting it in a different form, we find that

100 *lbs. of dry matter produced*

In fodder corn ration	78.7 lbs. of milk.
In silage ration	70.4 lbs. of milk.
Diff. in favor of fodder corn ration	8.3 lbs.
Or in per cent	12 per cent.

This is exactly the same result as obtained in last year's experiment, the dry matter in the fodder corn giving a 12 per cent. better result in the milk yield, or one pound of dry matter in the fodder corn ration produced the same results as 1.12 pounds of dry matter in the silage ration.

THE FINANCIAL SIDE OF THE QUESTION.

We shall now consider the relation between the milk produced by the cows on the experiment and the area of land from which the fodder fed in both cases was obtained. 165,824 lbs. of silage were obtained from the half of an $8\frac{2}{3}$-acre field. 64,643 lbs. were fed out of this to the cows on the experiment in connection with a daily ration of 4 lbs. of hay and 7 lbs. of grain feed per head; this feed produced 19,813 lbs. of milk. 31,738 lbs. of field cured fodder corn were obtained from the other half of the $8\frac{2}{3}$-acre field. 20,394 lbs. of this were fed during the experiment in connection with the same ration as above of hay and grain feed; 19,801.2 lbs. of milk were produced from this feed. Now it is fair to assume that the whole quantity of silage and fodder corn would have produced as much more milk as the total quantity of each feed is greater than what was actually fed on the experiment, with the quantity of hay and grain feed increased in the same proportion in both cases. We then calculate from the above figures how much milk would have been produced, had all the silage and fodder corn obtained from

the $4\frac{1}{3}$ acres of land been fed out, and how much hay and grain feed would have to be fed with the silage and with the fodder corn, these being fed in the proportions already stated. The following statement is the result of this calculation:

105,824 lbs. of silage and 7,136 lbs. of hay with 12,488 lbs. of grain feed would have produced 32,470 lbs. of milk.

31,738 lbs. of fodder corn and 6,784 lbs. of hay with 11,872 lbs. of grain feed would have produced 30,820 lbs of milk.

It would have taken twenty cows 89.2 days to eat all the silage obtained from the $4\frac{1}{3}$ acres, and 84.8 days to eat all the fodder corn from the same area; the daily ration of hay and grain feed being for the twenty cows 80 lbs. and 140 lbs. respectively, it would take the number of pounds given in the table of each feed to go with the silage and fodder corn. For the sake of better comparison we shall calculate the figures on the basis of the product from 1 acre of land, the quantity of milk fat given is calculated from the average percentage of fat found in the cows' milk when on silage and when on fodder corn:

From 29,800 lbs. of green fodder were obtained 24,440 lbs. of silage, which fed with 1,648 lbs. of hay and 2,884 lbs. of grain feed produced 7,496 lbs. of milk, containing 340.4 lbs. of fat, which would make about 374.4 lbs. of butter.

From 29,800 lbs. of green fodder were obtained 7,330 lbs of field cured fodder corn, which fed with 1,567 lbs. of hay and 2,743 lbs. of grain feed produced 7,119 lbs. of milk containing 318.2 lbs. of fat, which would make about 350 lbs. of butter.

Comparing the two sets of figures, we notice that the Indian corn from one acre when made into silage produced 377 lbs. of milk more than when the dry fodder from the same area was fed, 81 lbs. more of hay and 141 lbs. more of grain feed being fed with the silage. If the hay is worth \$7 and the grain feed \$15 per ton, this additional feed was worth \$1.34, and calculating the milk worth \$1 per cwt. we find that \$2.43 would be the net profit of the silage over the fodder corn from one acre of land. This is taking into account only the cost of the feeds and the product, without reference to the question of labor in handling the feed or of taking care of the cows in either case. The 243 lbs. of milk found to represent the net profit on the silage feeding would contain 11 lbs. of fat and

would correspond to about 12 lbs. of butter, which stands for the net profit of silage over fodder from one acre if butter is made.

It will be remembered that this result is obtained on an experiment with twenty cows that were fed the product of nearly two-thirds of an $8\frac{2}{3}$ acre field. Considerable confidence is therefore placed in the correctness of the results, and the general applicability of the conclusions drawn to the conditions of our general Wisconsin farmers. Summarizing our work in this line, we have the following conclusions:

1. A daily ration of 4 lbs. of hay and 7 lbs. of grain feed, with corn silage or field cured fodder corn ad libitum, fed to twenty cows during sixteen weeks produced a total quantity of 19,813.4 lbs. of milk during the silage periods and 19,801.2 lbs. of milk during the fodder corn periods.

2. When we consider the areas of land from which the silage and fodder corn fed were obtained, we find that the silage would have produced 243 lbs. more of milk per acre than the dry fodder, or the equivalent of 12 lbs. of butter. This is a gain of a little more than 3 per cent. in favor of the silage.

A PRELIMINARY EXPERIMENT ON THE INFLUENCE OF IMPERFECT VENTILATION UPON MILCH COWS.

F. H. KING.

In the construction of dairy barns we stand greatly in need of more exact data regarding the influence of ventilation, or the lack of it, upon milch cows, and this need becomes the more urgent as herds are increased in size and barns are more closely built.

The oxygen breathed by ourselves and by our domestic animals is procured so unconsciously and so inevitably, under most circumstances, that we rarely realize the important part it plays in the physiological processes, or the large quantity of it which is daily consumed. In our own case, the average adult uses daily 1.83 lbs. of oxygen; this is one-fifth of the total weight of all materials taken into the body daily, and to get it we must breath about 346 cubic feet of air. Though we do not know definitely the amount of oxygen required by cows, yet, with their much larger bodies and relatively larger lungs, they must demand a large amount of good air for the best work at the pail.

THE EXPERIMENT.

To study the relative effects of good and poor ventilation upon milch cows, 20 animals, on April 8th, were put upon a ration of 15 lbs. of sugar beets, 15 lbs. of silage, 4 lbs. of hay, 5 lbs. of bran, 2 lbs. of shorts, and what dry cut corn fodder they would eat, the amount left being weighed back. After a preliminary period extending to the 19th, the experiment proper began, and continued 14 days, which were divided into six periods, four of two days each, and

two of three days each, during which the cows were under the influence of good and poor ventilation during alternate periods, and continuously in the barn, except during the first two periods.

THE STABLE.

The animals stood in two rows facing opposite, in a stone basement 40x60 ft., 8 ft. high, and provided with thirteen large windows, three outside doors and one leading to the barn above. Two hay chutes 2x3 ft., 20 ft. high, opening at the ceiling, one above the heads of each row of cows near the center of the lines and closed by sliding doors, served as ventilators when open. A third ventilator similar to the others but 12x16 in. was always open. As a large portion of the space in the stable was unoccupied by the cows, a temporary partition of building paper was erected to reduce this space, but in it were left two full height doors, one of which was always open, and the other also during the periods of good ventilation.

The outside doors and windows, together with the two large ventilators, were kept closed during the periods of poor ventilation, but at other times windows and ventilators were open.

THE MILK YIELD.

Below are given the mean daily milk yields of the 20 cows during each of the six periods:

Table showing the mean daily milk yield.

Poor Ventilation.			Good Ventilation.		
Period.	Date.	Milk.	Period.	Date.	Milk.
		Lbs.			Lbs.
I	April 19, 20	305.20	II	April 21, 22	315.00
III	April 23, 24	311.40	IV	April 25, 26	324.00
V	April 27, 28, 29	309.03	VI	April 30, May 1, 2.	325.57
General average		308.54	General average		321.52

This table shows a mean daily milk yield of 12.98 lbs. for 20 cows and .649 lbs. per cow in favor of the conditions associated with good ventilation, which is an advantage of 4.21 per cent. It should be observed, however, that the table shows that some conditions were in operation during most of the experiment tending toward a continual general increase in the milk yield, and as the experiment begins with a period of poor ventilation, and closes with a period of good ventilation, this general increase adds an increment to the side of good ventilation not justly its due. To eliminate this increment, it will be necessary to compare the average of Periods I and III with Period II, and of Periods II and IV with Period III, etc. When this is done we get the results given in Table 2.

Table showing mean daily milk yield corrected for increasing lactation.

Poor Ventilation.		Good Ventilation.	
Periods.	Milk.	Periods.	Milk.
	Lbs.		Lbs.
I and III	308.30	II	315.00
III	311.40	II and IV	319.50
III and V	310.35	IV	324.00
V	309.03	IV and VI	324.79
General average	309.77	General average	320.82

This table shows that there is still a balance in favor of good ventilation amounting to 11.05 lbs. daily for the 20 cows, and of .551 lbs. per cow, or a percentage gain of 3.57.

THE WATER DRANK.

There was a marked difference in the amount of water drank by the cows while under the conditions of good and poor ventilation, as the following table will show, but during the first two periods the water was not weighed:

Table showing the mean daily amount of water drank per cow.

Poor Ventilation.			Good Ventilation.		
Period.	Date.	Water.	Period.	Date.	Water.
		Lbs.			Lbs.
III	April 23, 24	69.5	IV	April 25, 26	64.2
V	April 27, 28, 29	72.0	VI	April 30, May 1, 2.	54.4
General av		70.7	General av		59.3

It is here seen that the cows averaged 11.4 lbs. more water each per day under the conditions of poor ventilation.

TEMPERATURE OF THE STABLES.

The temperature was determined by a continuously recording thermograph placed near the ceiling, and the following table is deduced from its records:

Table showing the maximum, minimum, and mean temperature of the stable.

Poor Ventilation.				Good Ventilation.			
Period.	Max. Tem.	Min. Tem.	Mean.	Period.	Max. Tem.	Min. Tem.	Mean.
I.	76.5° F.	65° F.	71.9°	II	73° F.	61.5° F.	67.8°
III	77.5° F.	70° F.	72.5°	IV	76.5° F.	64° F.	69.2°
V.	80.5° F.	70° F.	75.3°	VI	69.5° F.	56.5° F.	63.6°
General	mean		73.2°	General	mean		66.9°

It will be observed that there was a difference of 6.3 ° F in the mean temperature of the stable during the good and poorly ventilated periods, and this difference probably explains, in part at least, the greater amount of water drank during the periods of poor ventilation. The cows apparently perspired much more freely during the times of poor ventilation, but the lack of rapid changes of air tended to exaggerate this appearance by allowing the moisture to accumulate as it could not have done under more rapid changes.

WEIGHT OF THE COWS.

During the last two periods, of three days each, the cows were weighed daily just before watering, and during the remaining four periods they were weighed the last day of each period.

The following table shows the average weights of the 20 cows as deduced from all the weighings of the several periods. As there had been a general, but small, gain in weight during the 14 days under consideration, the mean weights of Periods I and III are combined and compared with those of Period II, etc., as done with the milk:

Table showing the mean weight of the cows.

Poor Ventilation.		Good Ventilation.	
Periods.	Weight.	Periods.	Weight.
I and III	872.5	II	884.0
III	880 0	II and IV	887.5
III and V	879.5	IV	891.0
V	879.0	IV and VI	891.5
General average	877.75	General average	888.5

It will be seen that, in all cases, the mean weight of the herd increased under the conditions of good ventilation, while under the reverse conditions there was a loss, the average amount per cow being 10.75 lbs. for each change. It should be said here that the cows used on this experiment were the same ones which had been on the dry corn fodder and silage experiment reported on pp. 49–60, and that at the close of the preliminary period there had been a marked falling off in weight, the ten cows which had been on silage having lost between the 14th and 20th, an average of 42 lbs. per cow, and those on dry corn fodder 25 lbs., but the mean weight, on April 20, was still above that at which the cows went onto the dry corn fodder and silage experiment, in December, 1890. The falling off in weight noted

with the change from one experiment to the other, may be due in part to the change of ration, but it does not appear probable that it could have been wholly due to that, for other observations suggest that the cows which were changed from dry feed to that of silage and beets should have increased in weight, rather than have lost, as they did. Further than this, the preliminary period consisted of two intervals, one from April 8 to 14 inclusive, during which the cows were simply under the influence of change of feed, and the other, from the 14th to the 18th inclusive, during which the cows, on alternate days, were under the influence of good and poor ventilation. Now the mean weight of the cows during the six days just preceding this experiment was 899.5 lbs., six days later, just before going under the influence of poor ventilation, it was 893.5 lbs., but six days later still, at the close of the preliminary period, the mean weight had fallen to 865.3 lbs., showing that the major part of the loss in weight referred to dates from the beginning of the poor ventilation.

This marked shrinkage in weight, however, is not associated with a corresponding shrinkage in the milk yield, for the average daily milk yield, during the three days just preceding the experiment, was 314.2 lbs., and for the three days just before the period of poor ventilation, it was 321.6 lbs., while for the last three days of the period it was 325.6 lbs.

THE FOOD EATEN.

The differences in ventilation do not appear to have had an appreciable influence upon the quantity of food eaten for the amounts consumed, under both conditions, were ractically the same.

When the cows were turned out of the barn, at the close of the experiment, the majority of them exhibited a strong desire to scratch themselves. The irritation became so strong and was so persistent that many of the cows used their tongues with such energy as to cause the lower portions of the limbs and spots upon the body to bleed. An examination showed that the bleeding proceeded from

small eruptions which were chiefly confined to the lower limbs. When these eruptions first appeared, or what produced them is unknown. They were soon gone, and may have had no organic connection with the experiment.

ANOTHER EXPERIMENT.

Before the foregoing experiment had been tried, a preliminary one, covering a period of 122 days and involving the same cows together with five others, was conducted to see if a small difference in the amount of ventilation would produce a measurable effect upon the milk yield. It began December 8, 1890, and closed the 7th of April following. The cows occupied the stable already described, but without the partition. On alternate nights the two large ventilators mentioned were closed from 6 P. M. to 6 A. M., but at all other times they were open. Doors and windows were shut at night, but the small ventilator was never closed. During every day the ventilation was complete, and the cows had the freedom of the yard during pleasant weather. The thermograph placed as described, showed the highest temperature to have been 60° F., and the lowest 32° F., each of these temperatures having been reached but once, the usual range lying between 40° and 52° F.

In studying the effects of these changes, the milk of the morning and evening following the closing of the ventilators was counted most influenced by lack of ventilation. When the quantity of milk given December 8th, the ventilators having been open, is compared with that given the 9th, when they had been closed. and so on through the whole period, it is found that, of the 60 pairs of days, there are 33 when more milk was given with the ventilators open, and 26 days when more was given with them shut, there being a balance of 119.7 lbs. in favor of the best ventilation, an average of nearly 1 lb. per day for the whole period. On account of the ventilators being open on the first day and closed on the second, the natural shrinkage due to the lengthening of the period of lactation tends to make any influence poor ventilation may have had, appear larger than

it really is. To avoid this error the milk of the 8th was discarded and that of the 9th compared with that of the 10th and so on, this tending to give a result as much too small as the other is too large. When this comparison is made, it is found that of the 60 pairs of days there are 36 when more milk was given with the ventilators open and 24 when they were shut, but now with a balance of only 4.8 lbs. of milk in favor of the open ventilators. By taking half the sum of these two differences we eliminate as nearly as may be the effect of diminishing lactation and get 62.2 lbs. or one-half a pound of milk a day more associated with the open ventilators. The quantitative differences here are very small indeed, and can have but little significance in themselves, but the number of times more milk was given with ventilators open than with them closed, is larger, and may have a real significance, for of the 120 pairs of days we have 69 in favor of open ventilators, one case equal, and but 50 against them, a difference of 19 cases.

When it is observed that only 25 cows occupied a space in which ordinarily nearly twice that number are housed, that the cows were turned out of doors daily, and that the ventilators were closed only twelve hours in each forty-eight hours, and even then one ventilator 12x16 inches always open, the surprising feature is that any effect whatever should be indicated.

CREAMING EXPERIMENTS.

S. M. BABCOCK.

LOSS OF FAT IN CREAMING.

By whatever method milk is handled in the dairy or creamery, it is impossible to recover all of the fat which it contains in the butter made from it. At every step in the manufacture some loss of fat is incurred. There is a mechanical loss through the adherence of milk, cream, and particles of butter to the apparatus used, and there is always some fat left in the skim milk and buttermilk, no matter what methods of creaming and churning are practiced. The sum of these losses may be very large, or it may be insignificant, depending upon the system employed, and the skill and carefulness of the dairyman.

The chief object in undertaking the tests described in this Report was to compare the efficiency of the deep setting and centrifugal methods with different milks. Incidentally the effect of delay in setting, the use of ice, and some other questions have been studied. The thoroughness with which the fat has been removed from the skim milk has been taken as a measure of the efficiency of the creaming, and in order to make all tests directly comparable, the amount of fat in the skim milk has in all cases been expressed in pounds per one hundred pounds of milk set. Mechanical loss has not been considered, nor has the influence of the different methods of creaming upon the efficiency of the churn, except so far as the quantity of buttermilk may have been affected by the proportion of cream obtained with the different methods. In other

words, the "churnability" of all cream obtained in these tests has been assumed to be the same, and the amount of fat left in the buttermilk to be three-tenths of one per cent. in all cases. In computing losses the amount of buttermilk has been considered equal to the difference between the cream and the fat which the cream contains.

DEEP SETTING.

At the present time, a large proportion of the butter made in private dairies in Wisconsin, is from milk set in deep cans. Two styles of cans, namely the Cooley and the "Shotgun" can, are in general use. The same principles of creaming are involved in both, the only difference in efficiency arising from the method of skimming. With the Shotgun can, the cream is removed from the top by dipping, a conical dipper designed for the purpose being usually employed, while with the Cooley can the skim milk is drawn from the bottom, leaving the cream in the can. A number of trials made at this Station during the past winter and spring, showed no material difference in the efficiency of the two methods, if the skimming was carefully done, and the same amount of cream was taken in each case. More care, however, appears to be necessary in skimming the Shotgun can, and I believe in general practice the losses with this can are greater than with the Cooley can. The tests given in this Bulletin were all made with the Cooley can. It is believed, however, that they apply equally well to creaming with the Shotgun can.

HOW MUCH SKIM MILK SHOULD BE LEFT WITH THE CREAM IN SKIMMING COOLEY CANS?

In skimming Cooley cans it is customary to observe the number of inches of cream on the glass scale at the top of the can, and then to set the syphon at the bottom so that it will leave this amount or perhaps a little more in the can after the skim milk has been drawn out; rarely is more than one-half inch of skim milk left with the cream. A few tests of the last portion of skim milk drawn from a can, to

within about one-half inch of the cream line, showed it to be rich in fat, and indicated that considerable loss was incurred by this practice, which might be easily avoided by leaving more milk with the cream. The following trials were therefore made to determine the relative losses of fat when different amounts of skim milk were left with the cream. These experiments were conducted in the following manner. Skim milk was first drawn from the bottom of a can to within two inches of the cream line, this being carefully observed through a glass inserted in the side of the can near the bottom. This skim milk was weighed and a sample taken for analysis. Then one inch more of milk was drawn off, and after being weighed, set aside for analysis; finally one-half inch more of milk was removed, leaving one-half inch of skim milk with the cream. The analyses of these several portions of skim milk showed them to contain the following per cents. of fat, thirteen trials having been made in all:

Table showing maximum, minimum and average per cent. of fat in different layers of skim milk from Cooley cans.

	Max.	Min.	Average.
Bottom of can, to within 2 inches of cream line............	.6	.1	.292
The next inch, to within 1 inch of cream line...............	1.1	.15	.410
The next ½ inch, to within ½ inch of cream.........	7.10	.4	3.323

The increased per cent. of fat in the last portion of skim milk is probably due to currents which disturb the cream line and not wholly to imperfect creaming. The following table shows the per cent. of cream and loss of fat in skim milk expressed in pounds per 100 pounds of milk set, when skimmed to different depths, calculated from the average figures in last table:

Table showing per cent. of cream and loss of fat in skim milk when skimmed to different depths.

	Per cent. of cream.	Loss of fat in the skim milk from 100 lbs. of milk.
		Lbs.
Skimmed to within two inches of cream line	29.85	.213
Skimmed to within 1 inch of cream line	23.71	.238
Skimmed to within ½ inch of cream line	20.64	.338

In calculating the total loss incident to either method of skimming it is assumed that the amount of buttermilk in each case is equal to the difference between the total cream obtained and the fat which it contains. The average per cent. of fat in the milk set in these trials was 4.58 and the average per cent. of fat in buttermilk from churnings made about this time was .23. This is lower than the average throughout the country for buttermilk, and in order to be on the safe side there is supposed to be .3 per cent. of fat in buttermilk in all the tests which follow. Calculating the losses in buttermilk on this basis and combining them with the losses in skim milk given in the previous table we have:

Table showing amount of buttermilk and total loss of fat from 100 pounds of milk set when skimmed to different depths below the cream line.

	Butter-milk.	Fat in butter-milk.	Loss of fat in skim-milk and butter-milk.
	Lbs.	Lbs.	Lbs.
Skimmed to within 2 inches of cream line	25.47	.076	.289
Skimmed to within 1 inch of cream line	19.37	.058	.296
Skimmed to within ½ inch of cream line	16.40	.049	.387

This indicates that the loss is practically the same whether one or two inches of skim milk are left with the cream. There is, however, a very material increase in the

loss when another half inch of skim milk is drawn off. In the milk used the increased loss was more than 2 per cent. of the total fat in the milk set. This milk was richer than the average and consequently the percentage loss was less than would be found with ordinary milk containing 3.5 to 4 per cent. of fat. As a rule less than one-half inch of skim milk is left with the cream, the result of which must be a loss considerably larger than these trials show. It would probably reach, as milk is usually skimmed, two pounds of butter per 1,000 pounds of milk set, or for an average cow from eight to ten pounds of butter per year. As no extra expense is required to prevent this loss, the saving would be so much added to the profit of the cow.

We conclude that when deep setting is practiced the gauge should be set so that not less than one inch of milk will be left with the cream in the skimming. The increased loss where only one half inch of skim milk is left amounts to about .1 pound of fat for each 100 pounds of milk set. Skim milk drawn from within less than one-half inch of the cream line is mixed with about an equal volume of cream, and may be considerably richer in fat than the milk set.

INFLUENCE OF THE CHARACTER OF MILK UPON THE EFFICIENCY OF CREAMING BY DEEP SETTING AND BY THE CENTRIFUGAL PROCESS.

In order to obtain milks of different composition for this test, the Station herd was divided into five different groups, containing from four to six cows each. In arranging these groups, cows giving milk containing approximately the same per cent. of fat were put together. Lot 1 consisted of the cows giving the richest milk; lot two, those giving the next richest, and so on; lot 5 being those giving the poorest milk. The average per cent. of fat found in 20 tests of the mixed milk, from each lot, a short time before these experiments were commenced, was as follows:

	Per cent. of fat.
Lot 1	5.46
Lot 2	5.23
Lot 3	4.56
Lot 4	4.21
Lot 5	3.85

The milk from alternate milkings, from each lot, was creamed by the Cooley process, the other milkings being creamed by the Baby Separator, No. 2. We shall consider each system by itself, taking first,

THE DEEP SETTING SYSTEM.

In these trials the milk was set as soon as possible after milking, in ice water, and skimmed after standing from 15 to 24 hours, all of the lots at the same milking being treated, as nearly as possible, alike. They were skimmed to within two inches of the cream line. The per cent. of fat found in the skim milk from the different lots, ranged as follows:

Table, showing quality of milk and per cent of fat in skim milk, from Cooley cans.

Lot.	No. of trials.	Average per cent. fat in whole milk	Per Cent. of Fat in Skim Milk.		
			Max.	Min.	Average.
1	10	5.37	.15	.10	.12
2	10	5.14	.40	15	.28
3	10	4.44	.35	.20	.25
4	10	4.18	.35	.20	.26
5	10	3.82	.60	.25	.44

Table showing loss of fat in skim milk from the different lots.

Lot.	Loss of Fat per 100 Lbs. of Milk Set.			Average Per Cent. of	
	Max.	Min.	Average.	Cream.	Skim milk.
1	.102	.033	.080	34.67	65.33
2	.311	.080	.193	33.69	66.31
3	.239	.137	.176	31.89	68.11
4	.237	.137	.189	28.52	71.48
5	.452	.176	.324	28.72	71.28

Assuming, as in a previous case, that the amount of buttermilk is equal to the amount of cream less the fat which it contains, and that the buttermilk contains .3 per cent. of the fat, we derive the following:

Table showing loss of fat in buttermilk and total loss of fat in skim milk and buttermilk.

Lot.	Lbs. of buttermilk from 100 lbs. of milk.	Fat in buttermilk, lbs.	Total loss of fat per 100 lbs. milk set, lbs.
1	29.38	.088	.168
2	28.74	.086	.279
3	27.63	.083	.259
4	24.53	.073	.262
5	25.22	.076	.400

From this table there appears to be a general tendency for the rich milks to cream better than the poor milks, although the efficiency of creaming bears no definite relation to the amount of fat, the loss in lot 2 being nearly twice as great as that in lot 1, although there is little difference in the richness of the two milks. The difference in the amount of fat lost in lots 1 and 5 is equivalent to $2\frac{3}{4}$ pounds of butter for each 1,000 pounds of milk, which, at 20 cents per pound, would amount to $5\frac{1}{2}$ cents per hundred for milk.

The cows in all of these lots were treated alike, receiving the same food and care. The milks were handled in the same manner, care being taken to eliminate as far as possible all differences except those depending upon the character of the milk from the several lots. The number of cows in each lot was sufficiently large to overcome the individual peculiarities of any single animal and give to it the character of a herd, and judging from published reports, the range in loss of fat between these lots is considerably less than is often found between different herds.

THE BABY SEPARATOR.

Probably the greatest advance made in dairy practice in recent times is due to the introduction of centrifugal apparatus for the continuous separation of cream. Although the advantages of the separator have been generally acknowledged, its use in this country has been almost entirely confined to creameries and large dairies. This is owing chiefly to the first cost of the centrifuge and necessary power, coupled with the fact that considerable skill is required in the management of the large machines. A number of hand separators have been put upon the market, but most of them, although doing good work, have been too expensive and have required too much power to meet with general approval. One of the most recent of these hand machines is known as the "Baby Separator No. 2." This machine is cheaper, more compact, and when its capacity is considered, runs lighter than any other separator that I have seen. The machine which the Station owns will separate about 300 pounds of milk per hour and leave not more than .1 per cent. of fat in the skim milk. This is one-third as much as we can separate in our power De Laval machine if the same efficiency of creaming is reached. It turns easily and is easily cleaned, our dairyman preferring to separate the milk from our herd in this way to getting ice and cans ready for the deep setting. The cream obtained is neither frothed nor churned, but is as smooth as that from the deep setting. The machine has been in almost daily use for over two months without any expense for

repairs. For more than half of this time it has been run by a tread power upon which a yearling bull has been worked with advantage, as it has relieved a man for other purposes. It is so arranged that the bull is led into the tread just before milking time and as soon as three or four cows are milked the machine is started. No further care is required except to supply milk to the reservoir as it is milked. The creaming is completed in a short time after the last cow is milked.

Managed in this way the milk is in the best possible condition for separation, and the sweet skim milk still warm from the cow may be fed to calves or other stock. The bull used in this work is a Jersey and weighed at the beginning 510 pounds. He has steadily gained in weight and is undoubtedly better off for the exercise than he would have been without it. The tread power used is for two horses and has a governor which maintains a very steady speed and prevents accident which might occur from the running off of belts, etc. The power is set rather flat and is geared so as to give the driving pulley on the separator forty-two turns per minute. The manner in which the apparatus is arranged is shown in cut on opposite page. The skim milk is tested almost every day and rarely contains more than .1 per cent. of fat. In no case has it exceeded this when the milk was at the proper temperature.

In the tests given below, the Baby Separator was turned by hand, a metronome being used to assist in keeping a uniform speed of forty-two turns per minute. The milk used was from the Station herd which was divided into five lots, the same cows being in each lot as were in the tests of deep setting described in the previous pages, and in order to make the two tests comparable, as far as the general character of the milk was concerned, alternate milkings were taken for the deep setting and for the centrifuge. This arrangement was neccessary because the quantity of milk from each lot was too small to divide and have enough in each portion for a satisfactory test.

1.—Hand Separator run by bull on tread power.

In some cases the milk was separated immediately after milking, while the milk was still warm. In other cases it was allowed to stand two or three hours before skimming. Whenever the milk had cooled below 80° F., it was warmed to between 80° and 90° before separation. The skim milk from each lot was carefully tested for fat by the Babcock test, double quantity of milk being taken, in tubes designed for Short's test. In this way the reading could easily be taken to .1 per cent. with little error. In most cases the reading was marked under .1 per cent., but in order to be on the safe side, no values are taken less than .1. Careful gravimetric analyses were made in two cases which gave .08 per cent. of fat, thus confirming the results by the volumetric method. The uniformity of the creaming was remarkable, there being scarcely any variation either between milks of the same lot on different days, or between the different lots on the same day. In 35 trials, all except two gave a reading of .1 per cent. of fat, or less. In these cases the reading was .15 and .2. The loss of fat from each lot is given below. Seven trials were made with each lot of milk:

Table showing average loss of fat in skim milk from different milks when separated by the Baby Separator No. 2.

Lot.	Average per cent. of fat in milk.	Loss of fat from 100 lbs. of milk.			Per cent. of cream.	Per cent. of skim milk.
		Max.	Min.	Av.		
1.	5.7	.087	.083	.084	15.77	84.23
2.	5.3	.088	.081	083	16.50	83.50
3.	4.6	.087	.082	.084	16.16	83.84
4.	4.2	.088	.082	.084	15.60	84.40
5.	3.9	.166	.083	.103	15.05	84.95

Calculating the amount of buttermilk and the loss of fat in it on the same basis used in the deep setting, gives the following:

Table showing loss of fat in buttermilk and total loss of fat in skim milk and buttermilk.

Lot.	Buttermilk from 100 lbs. of milk.	Fat in buttermilk, lbs.	Total fat in skim milk and buttermilk from 100 lbs. of milk.
1	10.15	.030	.114
2	11.28	.034	1.17
3	11.64	.035	.119
4	11.48	.034	.118
5	11.25	.034	.137

The uniformly small loss of fat with this machine with milks of different character and under varying conditions, commends it to the attention of dairymen who keep a small number of cows and who are not near enough to a cheese factory or creamery to avail themselves of its advantages. The small capacity of the bowl gives it a special value for testing cows and for experimental work, as small quantities of milk (4 or 5 lbs.) can be creamed with it more perfectly than in any other way. Moreovor, it practically eliminates those individual or breed peculiarities which have a marked influence upon all systems of gravity creaming. This is well illustrated in the following:

Table showing comparative loses of fat from 100 *lbs. of different milks when creamed by centrifugal and deep setting.*

	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
Deep setting	.148	.257	.239	245	.382
Centrifugal	.107	.109	.110	.110	.129
Difference in favor of centrifugal	.041	.148	.129	.135	.253

In these trials with the deep setting, ice was freely used, and every precaution was taken to have the most favorable conditions, the milk being allowed to stand from 15 to 24 hours before being skimmed. Ordinarily, milk set in this way is skimmed in about 11 hours, so that the same cans

may be used for the next milking; such practice would add considerable to the total loss by this method.

The advantage of the separator is probably greater in actual practice than is shown in the above comparison, as the mechanical loss by this method is naturally less, there being no necessity for the transfer of cream from vessel to vessel, as is the case with deep setting. Moreover, the separator cream, being richer in fat than that from deep setting, is likely to churn more efficiently, it being a general rule that the richer cream is, so long as its consistency is not too great for effective churning, the greater will be the proportion of fat recovered in the butter. In our own experience, we have found that cream containing about 25 per cent. of fat churns most efficiently. If it is much richer than this it will be so thick, when properly ripened, that it cannot be churned with advantage in a box or barrel churn, as quantities of cream adhere to the sides and revolve with it, without being churned. When the butter finally separates, this cream is, to a large extent, mingled with the buttermilk and lost.

When the Baby Separator was first tried by us, the cream screw was so adjusted that the cream contained over 30 per cent. of fat. This cream, when ripened, was too thick to churn well, the buttermilk containing from 0.5 to 1 per cent of fat. By diluting this cream with about one-fifth its volume of water, the fat in the buttermilk was reduced to about .2 per cent., and in some cases as low as .15 per cent. This improvement I believe to be due entirely to having reduced the consistency of the cream to a point where it was uniformly churned. This is closer work than is usual with cream from deep setting, and warrants the conclusion th t centrifugal cream, containing about 25 per cent. of fat, will churn more efficiently than that from deep setting, which contains less than 20 per cent.

All things considered, 1½ lbs. of butter per day is a small estimate of the increased yield of butter from the Station herd of 20 to 25 cows, when the Baby Separator is used. This is equivalent to about two average cows. If ice were

not freely used and every precaution taken for efficient work, in the deep setting, the difference between the two systems would be still further increased.

I believe the Baby Separator can be used to advantage in herds containing 10 good cows, but for herds smaller than this would recommend the deep setting system, and would urge when the latter method is used that the milk be set immediately after milking and that sufficient ice be placed in the creaming tank to keep the temperature of the water below 50° F. in order to insure the most efficient work.

DELAYED SETTING.

The following trials were undertaken to determine whether the creaming of different milks would be similarly affected by delay in setting, when deep setting is used. The tests were made with milk from the same groups of cows used in the preceding experiment. In each trial the milk from each group of cows was mixed and divided, one-half of it being set immediately in ice water, the other half being set in the same tank after standing in the open air for periods ranging from 15 minutes to 3 hours. The delayed milk was mixed just before being put into the tank. The milks were skimmed in the same order in which they were placed in the tank, both the delayed and immediate setting being allowed the same time — usually 12 hours — for creaming. In most cases the milk was drawn off to within 2 inches of the cream line, although some milks were skimmed to within one inch. All comparative trials were skimmed in the same way. The same quantity of milk was always taken for the delayed as for the corresponding immediate setting. The size of cans used in different tests was either 18, 24 or 35 lbs., according to the amount of milk available. The cans were always filled full. No difference was found in the efficiency of creaming from the different sized cans. The following tables give the results:

Table showing average per cent. of fat in whole milk and in skim milk from immediate and delayed setting.

Lot.	No. of trials.	Average per cent. of fat in milk.	Per Cent. of Fat in Skim Milk.						Time delayed, minutes.
			Immediate setting.			Delayed setting.			
			Max.	Min.	Aver.	Max.	Min.	Aver.	
1........	5	4.90	.25	.10	.14	.40	.15	.22	15
2........	5	4.60	.80	.50	.65	1.00	.55	.83	15
3........	5	3.93	.40	.15	.24	.50	.15	.28	15
4	5	4.67	.30	.15	.25	.30	.20	.28	15
5........	7	3.40	.80	.20	.37	.80	.25	.39	15
1........	5	5 90	.30	.20	.27	.45	.25	.34	20—40
2........	5	4.90	.90	.70	.86	1.40	.90	1.20	20—40
3	6	4.34	.35	.20	.27	.40	.25	.34	20—40
4..	5	4.80	.45	.20	.27	.50	.20	.30	20—40
5.... ...	5	3.16	.80	30	.32	.80	.30	.35	20—40
1.... ..	8	5.26	.30	.15	.22	.50	.25	.38	Over 40
2	8	4.95	1.00	.30	.53	1.50	.50	.91	Over 40
3	8	4.40	.35	.20	.26	.70	.20	.39	Over 40
4	8	4.72	.35	.20	.25	.35	.20	.26	Over 40
5..... ..	6	3.23	.40	.30	.36	.50	.35	.43	Over 40
Herd....	8	4.94	.50	.20	.27	.25	.90	.37	Over 40

Table showing average loss of fat in skim milk from 100 lbs. of milk set immediately after milking and after delay.

Lot.	Set Immediately.		Delayed.		Time delayed, minutes.
	Lbs. of fat.	Per cent. cream.	Lbs. of fat.	Per cent. cream.	
1	.094	32.39	.146	33.94	15
2	.439	32.96	.533	38.58	15
3	.172	27.35	.197	29.00	15
4	.217	25.14	.205	26.24	15
5	.292	22.75	.303	23.66	15
Average for 15 minutes delay	.243	28.12	.277	30.28	
1	.177	35.36	.237	37.13	20—40
2	.581	34.12	.759	36.61	20—40
3	.195	27.76	.265	28.35	20—40
4	.192	28.26	.210	29.37	20—40
5	.306	20.38	.235	20 63	20—40
Average	.290	29.18	.361	30.42	
1	.151	33.35	.383	37.42	over 40
2	.439	33.64	.610	37.38	over 40
3	.189	27.65	.274	29.67	over 40
4	.185	26.93	.186	27.56	over 40
5	.279	21.81	.328	22.55	over 40
Herd	188	30.28	259	31.58	
Average	.238	28.94	.340	31.03	

Table showing the average loss of fat in the skim milk from all tests of each lot of milk.

Lot.	No. of trials.	Not Delayed.		Delayed.		Difference in favor of immediate setting.
		Lbs. fat per 100 lbs. milk set.	Per cent. of cream.	Lbs. fat per 100 lbs. milk set.	Per cent. of cream.	
1	18	.142	33.64	.277	36.41	.136
2	18	.439	33.64	.610	37.38	.171
3	19	.186	27.59	.251	29.08	.065
4	18	.195	26.90	.198	27.78	.003
5	18	.292	21.68	.320	22.45	.028
Herd	8	.188	30.28	.259	31.58	.071
Average of all	99	.245	28.80	.325	30.68	.080

Although on the whole these trials show considerable loss by delayed setting, their most interesting feature is the influence which delay has upon the creaming with different milks.

The loss by delay with milk from lot 4 was practically nothing; with lot 5 the loss was also very small; with lot 3 it was considerable: while with lots 1 and 2 it was very large, being largest of all with lot 2 The loss of fat from delay appears to be independent of the amount of fat in the milk, although as a rule it is somewhat larger in the rich milks than in the poor milks.

In these tests the delayed milk was placed in the milk room, no attempts being made to prevent its cooling. The temperature of the delayed milk when set, varied from day to day according to the temperature of the room and the time that the milk was exposed. The temperature of the milk set immediately ranged from 90° F. to 97° F., and averaged 95° F. for all trials when put in the ice water. The temperature of the milks delayed 15 minutes ranged, when put in the ice water, from 85° F. to 96° F., the average temperature being 92° F. The temperature of the milks delayed from 20 to 40 minutes ranged from 86° to 97°, and averaged 93°. The milks delayed more than 40 minutes ranged from 76° to 90°, and averaged 83° F.

A comparison of the milks from the same cows when set under like conditions, except that the temperature of the milks was different when they were put in the ice tank, indicates that the change in temperature, caused by the delay, has had comparatively little influence upon the creaming.

That the efficiency of the creaming by delayed setting is not materially improved by keeping the milk warm, is shown by the following tests in which the milk from each lot of cows was divided as before, one-half being set immediately after milking, and the other half after 30 minutes delay, the milk being kept warm until put into the tank:

Table showing the effect of delayed setting when the milk is kept warm.

LOT.	SET IMMEDIATELY.		DELAYED SETTING.			Dif. in favor immediate setting.
	Temp. of milk when set.	Loss of fat from 100 lbs. of milk.	Temp. of milk when set.	Loss of fat from 100 lbs. of milk.	Time delayed. min.	
	95	.172	98	.255	30	.083
2	94	.525	97	.782	30	.257
3	95	.203	95	.218	30	.015
4	95	.139	96	.176	30	.037
5	95	.198	94	.234	30	.036

The losses shown in this table are practically the same as were found in milks from the same lots of cows, set under the same conditions, except that they were allowed to cool. The natural inference is that the less efficient creaming by delayed setting is not caused by change of temperature alone, but chiefly by a change in the properties of the milk, which takes place very soon after milking if the milk is kept warm, and which is delayed or prevented by rapid cooling.

Recent trials made at the Maine and Cornell experiment stations to determine the influence of delayed setting upon the efficiency of the creaming, show practically no difference between the milk set directly after milking and that which was delayed. The results obtained with lots 4 and 5

are perfectly in accord with theirs, and had our observations been confined to these lots alone, the same conclusions would have been reached, viz.: "That with herds of ordinary size it will not be profitable to submit to any great inconvenience in order to place the milk in ice water immediately after it is drawn."

The two experiments agree further in showing that the cooling of milk several degrees before it is placed in ice water is not of much disadvantage to its creaming.

The difference in the creaming between the delayed and immediate setting, is shown in an entirely independent way by the quantity of cream obtained from the two milks. It is a general rule that where the separation of cream is retarded in any way, it will occupy more space than where it is not retarded. In the 99 trials made in these tests, 70 showed more cream from the delayed portions, 16 have the same amount upon both, and 13 showed more upon immediate setting.

In lots 1 and 2 where the most difference was found, every trial showed a larger volume of cream upon the delayed portion. In these two lots also every trial showed more fat in the skim milk from the delayed portion. In the ninety-nine trials, eighty-two gave more loss from the delayed; seven gave the same and ten gave more in the immediate setting. Lot 4 showed the least difference and lot 2 the most.

If the loss of fat in the buttermilk be considered, the difference in favor of immediate setting would be still more marked on account of the increased quantity of buttermilk from the delayed portions. Assuming as in previous tests, that the amount of buttermilk equals the difference between the total cream and the fat which the cream contains, and that the buttermilk contains .3 per cent. of fat, gives the total loss of fat from each lot of cows as found below:

Table showing loss of fat in skim milk and buttermilk by immediate and delayed settings.

Lot.	From 100 Pounds of Milk.						
	Immediate Setting.			*Delayed Setting.*		Fat in skimmilk and buttermilk.	Loss by delay.
	Butter-milk.	Fat in butter-milk.	Fat in skim milk and butter-milk.	Butter-milk.	Fat in butter-milk.		
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	28.44	.075	.217	31.35	.094	.371	.154
2	29.24	.088	.527	33.15	.099	.609	.182
3	23.51	.070	.256	25.06	.075	.326	.070
4	22.36	.067	.262	23.25	.070	.268	.006
5	18.69	.056	.348	19.49	.058	.378	.030
Remainder of herd	24.05	.072	.260	26.90	.080	.339	.079
Average	24.30	.073	.318	26.26	.079	.404	.086

These losses range from practically nothing in the case of lots 3 and 4 to enough butter fat to make more than two pounds of butter from 1,000 pounds of milk set, in the case of lot 2. The average for our whole herd of twenty-five cows is nearly one pound of butter per day in favor of immediate setting or a gain of one good cow in twenty-five without any extra expense and with no more trouble to the dairymen if the milk room is convenient to the stable.

Although these results show that delay in setting is not always accompanied by a loss in fat, they show the possibility of such loss and admonish all to carefully determine the peculiarities of their own herd before allowing the milk to stand around until the milking is completed. The safe way with all milks when creamed by deep setting is to place each can in ice water as soon as it is filled.

IS THE USE OF ICE PROFITABLE IN DEEP SETTING?

There is a general impression among farmers that water from a well or spring, especially if it is changed occasionally is cold enough to give a close creaming, and that when

such water is available, ice is unnecessary in a creaming tank. In this state the temperature of water in moderately deep wells ranges from about 45° F. to over 50° F. in summer. This temperature is probably low enough to give fairly good results, if it can be maintained for a sufficient time, but when ice is not used the temperature changes rapidly and will seldom be below 50°, and I believe as generally managed, is at least 55° when the milk is placed in it. The warm milk raises this still more, so that in a short time the temperature is much higher than is consistent with good work. On the other hand, where ice is used the initial temperature is usually below 45° and is maintained with little variation below this point, until the ice is all melted.

The influence which a range of temperature from ice water to 58° has upon the efficiency of the creaming is clearly shown in the following table:

Table showing loss of fat in skim milk by deep setting in water at different temperatures.

Temperature of water in tank.	Number of trials.	Av. loss of fat from 100 lbs. of milk set.— Lbs.	Loss per 100 lbs. of milk from cold water over ice.
Ice, 35°-45° F.	149	.232	....
48°	4	.297	.065
54°-56°	10	.746	.514
58°	5	.949	.717

These tests were all made with herd milk, which was set as nearly as possible under the same conditions, except that the temperature of the water in the tank varied. The milk was skimmed in from 11 to 12 hours as is our usual practice with ice. It is customary where well or spring water without ice is used to allow milk to set 24 hours or more before skimming. This naturally reduces the loss somewhat, but under the most favorable conditions the loss is excessive if ice is not used. I am confident that in most cases it is from one-half to one pound more per one hundred pounds of milk than where sufficient ice is used to maintain the temperature below 50° F. With a herd of ten

average cows this makes a difference, in favor of ice, of from 20 to 40 cents per day, if butter sells for 20 cents per pound. In most localities this would cover the necessary expense for ice and leave a large margin for profit.

CONCLUSIONS.

1. In skimming by the Cooley system, the syphon should be set so as to leave at least one inch of skim milk with the cream.

2. The efficiency of creaming by deep setting is greatly influenced by the character of the herd, the milk from some herds creaming very close, while that from other herds, under the same conditions, creams poorly. This difference may amount to as much as one pound of butter per 100 pounds of milk.

3. Delay in setting may cause a considerable loss with the milk from some herds and scarcely any with that of others. To avoid the possibility of such loss it is recommended that milk be set as soon as possible after milking.

4. Deep setting without ice under the most favorable conditions results in considerable loss, and where the water used is not lower than 50° F. the loss is excessive, reaching in some cases as much as 25 per cent. of the total fat in the milk.

5. The centrifugal system of separating cream overcomes all of these difficulties, giving an efficient creaming with milk from all sources, either directly after milking or after standing several hours.

6. The Baby Separator No. 2 may be used with advantage with herds of from 10 to 20 cows.

SOME EFFECTS PRODUCED BY ROLLING SPRING PLOWED LAND.

F. H. KING.

PREVIOUS WORK.

Field experiments, conducted at this Station, during the years 1889 and '90, together with other field observations in different portions of our state, made during the latter year, showed that rolling allows the temperature of tilled soil to become, at 1.5 inches below the surface, from 1° to 9° F., warmer than similar unrolled land in the same locality, and at 3 inches from 1° to 6° F. warmer. Other field studies showed that firming the surface of plowed land by rolling increases its power of drawing water to the surface, the effect being measurable at depths as great as 3 and 4 feet. It was further shown that, while rolling land increases the amount of *surface* moisture, still the land so treated becomes dryer, *as a whole*, to depths as great as four feet. In cases of broadcast seeding it was found that germination was more complete for oats, peas, barley and clover on the rolled than on the unrolled ground, and for oats the germination was more rapid also on the rolled land.

PLAN OF THE EXPERIMENT.

The study this year has been confined to oats and barley sowed with a Buckeye drill on spring plowed land. The drill was used to insure first, a more uniform seeding, and second, a more even and complete covering of the seed than is usual with broadcast sowing, and thus to eliminate this effect of the roller. Spring plowing was selected thinking that possibly the advantages of firming the soil might be greater than on fall plowing.

The land selected possessed a clay loam, underlaid at a depth of about four feet with a nearly pure sand; it was 27.7 rods long, contained nearly an acre, and was divided lengthwise, one-half being sowed to oats and the other to barley. The ground was plowed on April 28, and immediately afterward harrowed smooth and then seeded.

On the same day, two-thirds of each strip was rolled with an iron roller weighing 1,410 lbs. One-half of each rolled strip was then gone over once in a place with a light harrow. We thus had for each kind of grain first, one strip in which the seed was simply drilled in, second, one drilled and then rolled, and third, one drilled, then rolled and afterward harrowed. On each of these several strips eight plots were staked out, each 13 by 30 feet square and bounded by wires as shown in Fig. 2, so that exact duplicate areas could be selected for comparison, even in case the grain should lodge.

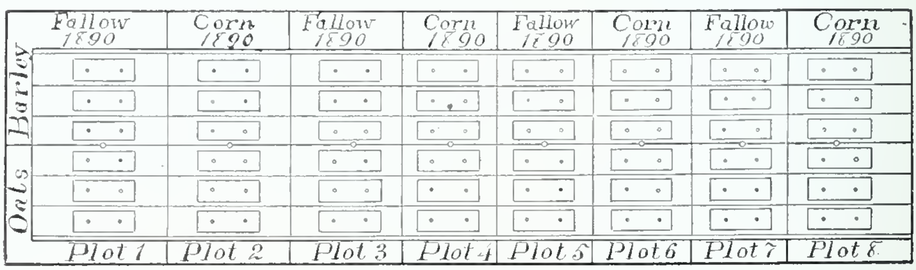


FIG. 2. Showing the arrangement of plots used in the experiments on rolling land. The small rectangles represent plots bounded by wires, and the dots in them where samples of soil were taken. The small circles on the central line are wells showing the depth of standing water in the soil.

INFLUENCE OF ROLLING ON THE GERMINATION.

On May 8, ten days after seeding, a comparative study of the germination was made by the method described in the Report of this Station for 1890, p. 127, with the following results:

	No. of counts.	No cases of germination.	Av. No. per unit area.
Barley, drilled simply	20	610	30.5
Barley, drilled and rolled	20	409	20.4
Barley, drilled, rolled and harrowed	20	498	24.9
Oats, drilled simply	20	1,046	52.3
Oats, drilled and rolled	20	659	33.0
Oats, drilled, rolled and harrowed	20	734	36.7

It is here seen that in both the oats and barley there is a much *smaller* germination on the *rolled* ground, whereas the results of last season, in every one of eight cases of *broadcast* seeding, were the reverse. Mr. R. Crossfield's experiment last season with *drilled* oats was in the same direction as my own this season but his difference was smaller, the ratio being 84 to 85; Mr. Crossfield's experiment however, was on fall plowed ground.

On May 12, four days later, a similar study was again made with the results below:

	No. of counts.	No. Cases of germination.	Av. No. per unit area.
Barley, drilled simply	20	1174	58.7
Barley, drilled and rolled	20	755	37.7
Barley, drilled, rolled and harrowed	20	1030	51.5
Oats, drilled simply	20	1247	62.3
Oats, drilled and rolled	20	1186	59.3
Oats, drilled, rolled and harrowed	20	1325	66.2

From these facts we may safely conclude that rolling both oats and barley after seeding with the drill had the effect of decreasing the amount of germination and of retarding it with the oats. The lengthening of the mean period of germination becomes more evident when the results are grouped as below:

	No. of Cases of Germination Per Unit Area.		
	Nine days after seeding.	Sixteen days after seeding.	Gain.
Barley, drilled simply	30.5	58.7	28.2
Barley, drilled and rolled	20.4	37.7	17.3
Barley, drilled, rolled and harrowed	24.9	51.5	26.6
Oats, drilled simply	52.3	62.3	10.0
Oats, drilled and rolled	33.0	59.3	26.3
Oats, drilled, rolled and harrowed	36.7	66.2	29.5

The data are insufficient to justify a positive assertion as to just why the rolling diminished the germination, but I believe it is due largely to insufficient aeration of the soil. The fact that there was decidedly better germination on the rolled ground which was harrowed seems to indicate that the difference was not due to too deep covering directly, for while the rolling would certainly cover the seeds more deeply, the light harrowing could not materially decrease that depth, but it did loosen the immediate surface which would tend to render it more easily penetrated by the oxygen which is essential to germination.

INFLUENCE OF ROLLING ON THE YIELD OF OATS AND BARLEY.

When the grain was ripe, that growing within the wires of the several plots was cut and the amount of dry matter determined by drying the entire crop immediately. The following table gives the computed yields per acre of oats and of straw, together with the per cent. of dry matter in each of the 24 plots of oats when cut:

Table showing the yield of oats and straw per acre aud the per cent. of dry matter.

No. of plot.	Drilled Simply.			Drilled and Rolled.			Drilled, Rolled and Harrowed.		
	Bushels per acre.	Pounds of straw.	Per ct. dry matter.	Bushels per acre.	Pounds of straw.	Per ct. dry matter.	Bushels per acre.	Pounds of straw.	Per ct. dry matter.
1.........	75.0	3835	43.79	69.11	3957	40.33	71.6	4371	40.37
2.........	72.7	3335	47.48	77.2	3500	50.16	80.3	3514	48.44
3.........	77.1	3341	43.62	76.7	3418	46.25	76.0	3852	51.91
4........	77.5	3453	43.35	74.7	3533	48.78	77.2	3835	48.87
5.........	71.2	3515	47.36	79.9	3606	49.20	76.4	4042	49.15
6.........	77.2	3920	43.22	72.1	3860	43.03	65.4	4012	40.95
7.........	70.3	3860	37.09	76.5	4414	41.08	66.5	4623	41.09
8.........	64.2	3894	43.84	68.1	3551	50.67	73.5	3837	50.97
Averages	73.2	3645	43.72	74.3	3734	46.20	73.36	4011	46.47

This table shows very clearly that the yield of oats per acre is practically the same on the soil having the three kinds of treatment. It is not so, however, with the yield of straw per acre, neither is it with the per cent. of dry matter, for in both of these cases, the oats were not only nearer ripe on the two rolled strips but the weight of dry matter in the straw was also greater, the difference being 89 lbs. per acre greater on the rolled and 336 lbs. greater on the rolled and harrowed than on that which was simply drilled in.

An accident happened to the barley from a portion of the plots which prevents a full statement, similar to that given for the oats, being made. There was, however, a very marked effect exerted by the rolling upon the growth of the barley, which became manifest early in the season and remained so until the grain was ripe. The barley on the ground which was drilled and rolled, was decidedly behind both that which was simply drilled and that which was rolled and harrowed after drilling. The straw was decidedly shorter on the rolled ground as well as standing much thinner, so much so, that the clover, to which the ground was seeded, was manifestly ahead of that on either

of the other strips. The following figures show the total yields of dry matter per acre on four of the simply drilled plots and four of those which were rolled after being seeded:

	Drilled Simply.	Drilled and Rolled.	Difference.
	Dry Matter Per Acre.	Dry Matter Per Acre.	
Plot 5	4700.8 lbs.	3796.6 lbs.	904.2 lbs.
Plot 6	4661.0 lbs.	3803.6 lbs.	857.4 lbs.
Plot 7	5671.0 lbs.	4331.3 lbs.	1339 7 lbs.
Plot 8	4048.6 lbs.	3714.5 lbs.	334.1 lbs.
Average	4770.35 lbs.	3911.5 lbs.	858.85 lbs.

These results indicate a diminished yield of dry matter per acre, amounting to 858.85 lbs. or 21.85 per cent., associated with rolling the ground after seeding with barley.

The seed which was procured for this experiment was found to be not entirely free from oats, and as soon as these began to head it became very evident that there would be a much larger proportion of oats in the barley which was rolled after seeding. At the time of cutting, the oats were removed from the barley and the amount of dry matter in them determined separately with results given below:

	Drilled and Rolled.	Drilled Simply.	Difference.
	Dry matter per acre.	Dry matter per acre.	
Plot 5	515.5 lbs.	263.8 lbs.	251.7 lbs.
Plot 6	446.4 lbs.	351.8 lbs.	94.6 lbs.
Plot 7	496.6 lbs.	332.3 lbs.	164.3 lbs.
Plot 8	562.8 lbs.	310.5 lbs.	252.3 lbs.
Average	505.33	314.6	190.73

These figures show that the rolled ground had produced 190.7 lbs. or 60.3 per cent. more oats per acre with the barley than the simply drilled ground did. This excess of

oats I believe to be due to the thinner and weaker condition of the barley which gave the oats a chance to start and develop more completely than where the barley stood thicker, and stands as another fact testifying to the bad effect associated with rolling the barley after sowing with the drill.

The ground which had been harrowed, after rolling, produced a larger yield of barley per acre than the simply drilled plots did, but the loss of all the grain growing within the staked areas, in this case, made it impossible to say just how large the yield was. An effort was made to get a comparative measure of the yields from the ground treated in the three ways by comparing the grain not included within the staked areas and as closely as the comparison could be made, which at best is only approximate, the yields, after deducting the oats growing with the barley, were:

Barley drilled simply	33 42 bu. per acre.
Barley drilled and rolled	30.74 bu. per acre.
Barley drilled, rolled and harrowed	38.07 bu. per acre.

The actual observed yields including oats were:

Barley drilled simply	37.12 bu. per acre.
Barley drilled and rolled	36.82 bu. per acre.
Barley drilled, rolled and harrowed	42.44 bu. per acre.

But as the effect of the rolling upon the barley was very different from what it was upon the oats the latter should be excluded, as has been done in the comparison above.

These figures show that the ground which was rolled and then harrowed was markedly ahead, in yield of barley per acre, of that receiving the other two methods of treatment, and it should be noted here that the largest amount of dry matter per acre, in the case of the oats, was also produced upon land receiving this treatment although the number of bushels of grain per acre, in the case of the oats, was practically the same on the three plots.

WATER CONTENT OF THE SOIL.

Immediately after cutting the grain, two samples of soil were taken, from each of the 48 plots, in one-foot sections extending from the surface to a depth of four feet, to see whether or not there was a measurable difference in the water left in the soil under the three types of treatment. The following table contains the results of these determinations:

Table showing the per cent. of water left in the soil at the end of the growing season.

Depth.	Water in Oat Ground.			Water in Barley Ground.		
	Drillled, rolled and harrowed.	Drilled and rolled.	Drilled simply.	Drilled simply.	Drilled and rolled.	Drilled, rolled and harrowed.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
1st foot	9.28	9.79	10.36	12.47	11.69	11.83
2d foot...........	13.55	14.35	14.41	15.84	16.00	15.85
3d foot...........	13.21	12.96	13.25	13.76	14.60	14.59
4th foot..	11.52	11.69	12.08	16.00	14.92	16.73
Average..	11.89	12.20	12.53	14.52	14.30	14.75

At the time of seeding in the spring samples of soil were also taken and then very little difference in the water content of the soil existed. The table shows that while the drilled and rolled ground, in both cases, contained less water at the end of the growing season than the simply drilled ground did, yet the difference is too small to suggest that the influence of rolling upon the rate of evaporation from the soil persists throughout the growing season. The other figures in the table, when taken in connection with the larger amounts of dry matter, per acre, produced by the rolled and harrowed strips, do suggest that the influence of harrowing after rolling may have had an effect in checking the rate of surface evaporation which lasted through the season, but the data at hand is yet insufficient to warrant such a conclusion being drawn.

The larger per cent. of water left in the barley ground is due partly to the earlier cutting of that grain, partly to the less amount of dry matter produced per acre and partly to the fact that less water is required for a pound of dry matter. The less thorough drying of the soil by the barley than by the oats, explains in a large measure, why a much better catch of clover is usually secured with the former crop.

INVESTIGATIONS RELATING TO SOIL MOISTURE.

F. H. KING.

INFLUENCE OF SPRING PLOWING IN CHECKING THE EVAPORATION OF SOIL WATER.

When ground is plowed in the spring and a stratum of soil 4 to 6 inches in depth is shaved completely from that below and reversed in a loose condition upon it, there is thus provided a covering which acts as a strong mulch, checking in a marked degree the loss of water by evaporation from the undisturbed soil below. During the past spring a series of observations were made in the field to determine quantitatively the influence of early spring plowing in checking the loss of water by evaporation.

On April 28 a piece of corn ground was plowed and sowed at once to oats and, on the next day, samples of soil were taken, in one foot sections, down to a depth of four feet. On May 6, seven days later, samples of soil were again taken and the water content in both cases determined with the following results:

	1st foot.	2nd foot.	3rd foot.	4th foot.
	Per cent.	Per cent.	Per cent.	Per cent.
Water in soil, April 29	20.13	22.61	20.51	17.72
Water in soil May 6.	19.86	23.24	20.86	17.17
Amount of change	—.27	+.63	+.35	—.55

These figures show that there had been very little if any change in the water content of the soil, the rate of capillary movement upward nearly keeping pace with the evaporation from the surface.

Side by side with this piece of ground was another which had not been plowed, separated from it by a strip of grass only ten feet wide. On May 6, at the same time the above set of samples were taken, another series were taken on the unplowed ground, each series consisting of eight samples taken in four pairs along parallel lines about 20 feet apart. The following figures show the water content, per cubic foot, in the plowed and unplowed ground computed from the observed percentages of soil water and the dry weight of the soil, the same weights of soil being taken for corresponding feet in the two series:

	Plowed ground.	Unplowed ground.	Difference.
First foot	13.87 lbs. water.	10.58 lbs. water.	3.29 lbs. water.
Second foot	20.66 lbs. water.	17.98 lbs. water.	2.68 lbs. water.
Third foot	18.33 lbs. water.	17.28 lbs. water.	1.05 lbs. water.
Fourth foot	16.05 lbs. water.	13.94 lbs. water.	2.11 lbs. water.
Sums	68.91 lbs. water.	59.78 lbs. water.	9.13 lbs. water.

It is thus shown that the unplowed ground contained, in the upper four feet, 9.13 lbs. less water than did the plowed ground on May 6, an equivalent of 1.75 inches of rainfall. It is unfortunate that samples of soil had not been taken on the unplowed strip April 29; those taken on the plowed strip were procured for another purpose and by chance simply, became available for comparison in this study. There is, however, no reason to suppose that the water content in the two pieces of ground was essentially different on April 28, for the samples are taken so close together and in so many places as to preclude a difference in the character of soil from affecting the results. Both pieces of ground were equally well drained and the season before the unplowed ground had grown potatoes while the plowed ground had grown corn, so that if any difference in water content was to be expected, the unplowed ground should have been the wetter.

As a check upon the foregoing observations, samples of soil were taken from three other localities on plowed and

unplowed land. In each of the three cases to be cited the plowed land was the best drained and, on this account, should, at the time of the comparison, be the dryest. In No. 1 the plowed ground had borne clover the year before and was plowed late in the fall, while the unplowed ground had borne corn and had not been plowed May 14 when the samples were taken. No. 2 was like No. 1. In No. 3 the plowed ground had borne corn the previous season and was plowed April 28, while the unplowed ground had borne sugar beets. In each of these three cases samples were taken in foot sections to a depth of three feet and each sample was a composite of two. The samples from the plowed and unplowed ground were taken at distances of about 30 feet apart, the character of the soil being the same for each locality except in the points stated:

	Plowed ground.	Unplowed ground.	Difference.
	No. 1.		
First foot	22.72 per cent. water.	19.49 per cent. water.	—3.23
Second foot	24.01 per cent. water.	24.62 per cent. water.	+ .61
Third foot	25.35 per cent. water.	26.08 per cent. water.	+ .73
	No. 2.		
First foot	22.88 per cent. water.	19.76 per cent. water.	—3.12
Second foot	24.38 per cent. water.	21.82 per cent. water.	—2.56
Third foot	22.75 per cent. water.	25.65 per cent. water.	+2.95
	No. 3.		
First foot	23.18 per cent. water.	17.93 per cent. water.	—5.23
Second foot	23.27 per cent. water.	21.17 per cent. water.	—2.10
Third foot	22.71 per cent. water.	23.99 per cent. water.	+1.28
Average	23.47	22.28	—1.19

It is thus evident from these three cases also that more water has been evaporated from the unplowed than from the plowed ground and this too, when two of the cases cited were fall plowing. The surface foot, in each of these cases, is decidedly dryer on the unplowed ground, the difference amounting to 2.7 lbs. per sq. ft. The wetter condition of the soil in the third foot in each case of unplowed ground I believe should be attributed to less perfect under drainage and that the actual difference in the amount of evaporation

from the two kinds of surface is much greater than the figures themselves indicate.

When it is observed that, in our state, the amount of water available for crop production, on almost all lands, is less than that which can be used to the best advantage, when one year is taken with another, these facts have an important bearing upon problems of tillage. They teach that, where corn and potato ground are to be plowed in the spring, the plowing should be done just as soon as the soil is dry enough to permit of it, and that, where corn is to be planted upon fall plowing, the disc harrow or similar tool should be used upon this ground as early as practicable to avoid a needless loss of water by surface evaporation.

EARLY TILLAGE TO PREVENT THE FORMATION OF CLODS.

The prevention of excessive waste of soil water is not the only important gain which results from early spring tillage. With all clay soils and clayey loams there is a certain degree of dryness at which they work with the least resistence, and are at the same time left in the best possible tilth; as these soils pass from the excessively wet stage through the stage of best moisture to that of too little they shrink and draw together into the larger or smaller clods which are so annoying, so productive of labor, and so preventive of large yields. The ground referred to in the experiment just described as being plowed on April 28, was left in excellent tilth, but that which, side by side with it, laid eight days longer before plowing, had developed in it, during that time, great numbers of clods of extreme size and excessive hardness, and as a consequence it became necessary to go over this ground twice with a loaded harrow, twice with a disc harrow, and twice with a heavy roller before it was brought into a condition of tilth only approximating that which [illegible] have had had it been plowed on April 28. Not only did the delay in plowing increase four fold the labor of fitting the ground, but it at the same time resulted in an unnecessary waste of water which was really large and greatly needed.

RISE OF WATER IN NATURAL FIELD SOIL FROM BELOW A DEPTH OF FIVE FEET.

It is a matter of common knowledge that the soil and subsoil, so far as they are penetrated by the roots of plants, act conjointly as a reservoir to store moisture for the use of vegetation during the growing season. Most of the roots of our cultivated plants, excluding shrubs and trees, are confined to a zone scarcely deeper than four or five feet. It becomes a matter of practical importance, therefore, in studying the best methods for conserving and utilizing soil-moisture, to know from what depth, below five feet, soil-moisture may be brought up into the root zone.

An effort was made the past summer to approach this question from the side of natural field conditions, and the results of the study are here given.

On May 14 a piece of fallow ground seven feet square, kept entirely free from weeds, was covered so as to exclude all rain and sunshine from it, but so as to permit a free circulation of air over the surface. The water content of the soil was determined at the same time to a depth of five feet which, when expressed in pounds per cubic foot, was as given below:

	1st ft.	2nd. ft.	3rd ft.	4th ft.	5th ft.
Water per cu. ft	7.99 lbs.	17.30 lbs.	14.86 lbs.	13.47 lbs.	8.82 lbs.

On July 17 and on Sept. 30, samples of soil were again taken to a depth of 7 feet and the amount of water per cubic foot is given below:

	1st ft.	2nd ft.	3rd ft.	4th ft.	5th ft.	6th ft.	7th ft.
	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.
July 17.....	9.03	14.63	14.37	13.26	8.52	9.87	19.79
September 30	6.05	14.50	11.90	11.86	6.30	3.51	15.55
Loss..........	2.98	.13	2.47	1.40	2.22	6.36	4.24

In another locality, where samples were taken July 25 and again Oct. 2, but which was wholly unsheltered and fallow, the results were as here given:

	1st ft.	2nd ft.	3rd ft.	4th ft.	5th ft.	6th ft.	7th ft.
	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.	lbs. water.
July 25.............	10.44	16.91	14.81	10.38	7.82	13.66	22.29
October 2..........	9.49	16.27	14.41	6.99	7.74	7.85	19.35
Loss........ ...	.95	.64	.40	3.39	.08	5.81	2.94

It will be seen from these results that, in both cases, the sixth and seventh feet had lost quite large amounts of water. Standing water in the ground occurred at about 7.6 feet below the surface when the first set of samples were taken and at about 8.4 feet when the last samples were taken in both localities. Unless it shall be shown by future study that these soils became dryer by a downward movement of the capillary water or by internal evaporation, what evidence we have goes to show that sub-soils six and seven feet below the surface may contribute large amounts of water, with the minerals they hold in solution, for the use of vegetation at the surface. It should be observed, in connection with the last locality cited, that a rainfall of 10.84 lbs. per sq. ft. had occurred, without percolation, as ordinarily understood, during the interval in question which probably accounts for the apparent smaller evaporation. In both localities the surface soil was a sandy clay loam running into a nearly pure sand at four feet below the surface.

INFLUENCE OF SURFACE TILLAGE UPON THE RATE OF EVAPORATION.

We are fast coming to believe that surface tillage diminishes the rate of evaporation from the soil but as yet we are without positive data in regard to just how great this saving may be.

To study this question quantitatively, in the field, five strips of land 12 feet wide and 130 feet long were plowed and

harrowed in the spring and two of them, alternating with the other three, were rolled May 14 and afterwards not disturbed except to shave off, without loosening the soil, such weeds as came up. The other strips were cultivated frequently to a depth of about three inches until July 13. All the strips were fallow and the soil was a sandy clay loam underlaid, at four feet, with a rather coarse and nearly pure sand. Standing water occurred in the ground at a depth varying from about 6.5 feet to 7 feet below the surface on May 29 and had fallen not far from .5 of a foot on July 17.

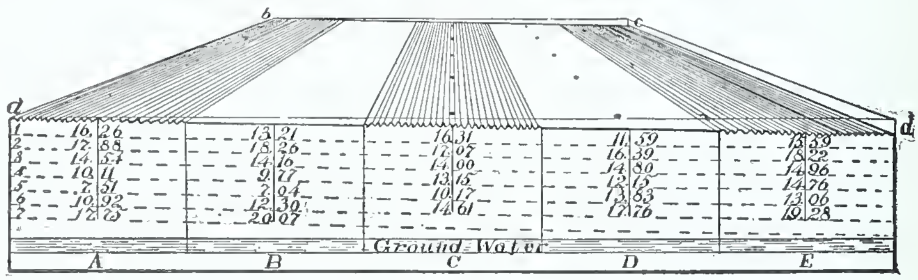


FIG. 3. Showing slope of the plots, the position of the ground water, the position where samples of soil were taken, and the per cent. of water in the soil at different depths on July 25.

The data given in the following table were obtained by taking samples of soil from plots D, and C, Fig. 3, in one foot sections to the depths indicated in the table on the dates there stated, and determining the water content by drying. The figures there given are derived from samples taken in five pairs from as many localities on the two plots, as indicated in Fig. 3. The samples, on the different dates, were all taken within a radius of ten inches of one another in the several localities, so as to make them as closely comparable as possible.

Date.	Depth of sample.		1st foot.	2nd foot.	3rd foot.	4th foot.	5th foot.	6th foot.	Total lbs. of water.	Rain in lbs. per sq. foot
	Mean weight of dry soil per cubic foot in pounds	....	79.00	92.62	104.59	106.21	111.06	111.06	....	....
May 29	Cultivated...	Per cent..	17.21	16.41	14.29	12.00	......	.....	....	....
		Pounds...	13.60	15.20	14.95	12.75	......	.. ..	56.50	. ...
	Uncultivated	Per cent..	15.37	16.64	14.48	11.29	......	......	....	....
		Pounds...	12.14	15.41	15.14	11.99	......	......	54.68	......
June 9	Cultivated...	Per cent..	16.86	15.80	14.12	10.06	8.79	16.42	....	....
		Pounds...	13.32	14.64	14.77	10.68	9.76	18.24	81.41	6.4 lbs
	Uncultivated	Per cent..	13.60	13.74	14.25	9.85	10.26	18.97	....	....
		Pounds...	10.74	12.73	14.90	10.46	11.39	21.07	81.29	....
June17	Cultivated...	Per cent..	15.95	16.07	14.38	10.31	8.61	15.96	.. ...	....
		Pounds...	12.60	14.89	15.04	10.95	9.56	17.73	80.77	.1 lbs
	Uncultivated	Per cent..	12.04	14.13	14.45	10.14	10.31	19.38	....	....
		Pounds...	9.51	13.09	15.11	10.77	11.45	21.52	81.45	....
June20	Cultivated...	Per cent..	19.01	16.83	13.99	10.54	8.06	15.29	....	....
		Pounds...	15.02	15.59	14.63	11.19	8.95	16.98	82.36	3.9 lbs
	Uncultivated	Per cent..	15.03	14.76	14.55	10.25	10.18	17.85	....	....
		Pounds...	11.87	13.67	15.22	10.89	11.31	19.82	82.78	....
July 17	Cultivated ..	Per cent..	14.06	15.92	14.63	10.59	9.29	16.39	....	....
		Pounds...	11.11	14.75	15.30	11.25	10.32	18.20	80.93	18.6 lbs
	Uncultivated	Per cent .	11.79	14.17	13.86	9.73	8.61	17.76	. ...	....
		Pounds...	9.31	13.13	14.50	10.33	9.56	19.72	76.55	....

It will be observed, from the figure, that there is a slope of the surface from A toward D which amounts to 1.7 feet in 100 feet. The surface of standing water in the ground also slopes, in the same direction, but at the rate of only .25 feet in 100 feet. At each time samples were taken the holes were carefully closed by wooden corks to prevent evaporation from them and the entrance of water from the surface.

At the time the surfaces of the plots were put under different conditions, on May 14, samples of soil were not taken, but in case there was any difference in the water content at that time, plot C should be expected to be a trifle dryer than plot D, because its surface was a little further above standing water in the ground.

The samples taken on May 29 only extended to a depth of four feet, but after this a longer soil tube was procured and the samples were then taken to a depth of six feet. If we compute the amount of water in pounds per cubic foot, from the weight of the dry soil, as given in the table, and the observed percentages of water in the soil, we get, for the upper four feet on the several dates, the results given below:

	Cultivated.	Uncultivated.	Difference.
On May 29	56.50 lbs.	51.68 lbs.	—1.82 lbs.
On June 9	53.41 lbs.	48.83 lbs.	—4.58 lbs.
Change in 11 days	—3.09 lbs.	—5.85 lbs.	
Rainfall	6.40 lbs.	6.40 lbs.	
Observed loss	9.49 lbs.	12.25 lbs.	
On June 9	53.41 lbs.	48.83 lbs.	
On June 17	53.48 lbs.	48.48 lbs.	—5.00 lbs.
Change in 8 days	+.07 lbs.	—.35 lbs.	
Rainfall	.10 lbs.	.10 lbs.	
Observed loss	.03 lbs.	.45 lbs.	
On June 17	53.48 lbs.	48.48 lbs.	
On June 20	56.43 lbs.	51.65 lbs.	—4.78 lbs.
Change in 3 days	+2.95 lbs.	+3.17 lbs.	
Rainfall	3.90 lbs.	3.90 lbs.	
Observed loss	.95 lbs.	.73 lbs.	
On June 20	56.43 lbs.	51.65 lbs.	
On July 17	52.41 lbs.	47.27 lbs.	—5.14 lbs.
Change in 27 days	—4.02 lbs.	—4.38 lbs.	
Rainfall	18.60 lbs.	18.60 lbs.	
Observed loss	22.62 lbs.	22.98 lbs.	

There is thus shown, on July 17, a difference in the water content of the upper four feet of soil amounting to 5.14 lbs. for each column of soil one foot square in section and four feet long, while on May 29, the difference was only 1.82 lbs., and when, presumably if there was any difference, it was on May 14, in the opposite direction.

It will also be seen that the observed loss between June 17 and June 20, when the samples were taken shortly after a rain of 3.9 lbs. per square foot, was a little greater on the cultivated ground than it was on the uncultivated. This is as should have been expected because the amount of surface exposed to evaporation was greater on the more uneven cultivated ground.

If we study the changes which occurred in the 5th and 6th feet during the intervals when samples were taken we shall get the result given below:

	Cultivated.	Uncultivated.	Difference.
On June 9	28.00 lbs.	32.46 lbs.	+4.46 lbs.
On June 17	27.29 lbs.	32.97 lbs.	+5.68 lbs.
Change in 8 days	—.71 lbs.	+.51 lbs.	
On June 17	27.29 lbs.	32.97 lbs.	
On June 20	25.93 lbs.	31.13 lbs.	+5.20 lbs.
Change in 3 days	—1.36 lbs.	—1.84 lbs.	
On June 20	25.93 lbs.	31.13 lbs.	
On July 17	28.52 lbs.	29.28 lbs.	+.76 lbs.
Change in 27 days	+2.59 lbs.	—1.85 lbs.	

If we now bring together the observed losses of water from the cultivated and uncultivated ground we shall obtain a measure of the influence of cultivation upon the rate of evaporation from the soil. Doing this we get the following losses:

	From cultivated ground.	From uncultivated ground.
May 29 to June 9	—9.49 lbs.	—12.25 lbs.
June 9 to June 17	—.74 lbs.	+ .06 lbs.
June 17 to June 20	—2.31 lbs.	—2.57 lbs.
June 20 to July 17	—20.03 lbs.	—24.83 lbs.
Total losses	32.57 lbs.	39.59 lbs.

It is thus shown that during 49 days the uncultivated ground dried

$$39.59 \text{ lbs.} - 32.57 \text{ lbs.} = 7.02 \text{ lbs.}$$

more than the cultivated ground did. When the first samples were taken, 15 days after the experiment began, the uncultivated ground was found 1.82 lbs. drier than the cultivated. If we assume that, at first, the water contents in the two cases were equal, and this may be done without violence for theoretically the cultivated ground should have been drier because it is further from the water table, we find that during 64 days for each column of soil one square foot in section and six feet long, the uncultivated ground had dried

$$7.02 + 1.82 = 8.84 \text{ lbs.}$$

more than the cultivated.

Computing, from the observed losses, the mean daily rate of evaporation per square foot from the surfaces in the two conditions we get,

For cultivated

$$\frac{32.57}{49} = .665 \text{ lbs. per sq. ft.}$$

For uncultivated

$$\frac{39.59}{49} = .808 \text{ lbs. per sq. ft.}$$

and this is the amount of water over and above that which may have been brought into the upper six feet of soil, from below, by capillary action.

A saving of 8.84 lbs. per square foot is equivalent to a rainfall of 1.7 inches, and amounts to 385,070 lbs. per acre. Observations, reported in another place, show that about

301.49 lbs. of water are required for a pound of dry matter in corn, and if this is true the above saving of water, in times of shortage, should increase the yield of dry matter per acre 1,277 lbs. which is about 14 per cent. of a good yield.

It should be observed that the retaining of water already in the ground, to the extent indicated above, must be much more serviceable to crops than to have an equivalent amount added to the surface in the form of rain, for in all such cases a very large portion of that, especially in dry times, is returned at once to the air without passing through the crop.

INFLUENCE OF FARM-YARD MANURE ON THE MOVEMENT AND AMOUNT OF WATER IN SOIL.

It has thus far appeared very difficult to account for the influence of many fertilizers upon the yield of crops on the supposition that they simply supply a deficiency of plant food to the soil, for very often their effects appear decidedly disproportionate to the amounts added, and they have often been found beneficial also when a chemical analysis of the soil reveals what appears to be even an over abundance of plant food.

Side by side with the experiments just described an effort was made by similar methods and on plots of the same size to ascertain whether farm-yard manure exerts an appreciable influence over the capillary movement of water and the quantity of it in soils. Four strips of land 12 feet wide and 130 feet long, one of which was manured by plowing under a heavy dressing of horse manure containing much coarse litter, and another by plowing under green cow manure and then adding a light surface dressing of thoroughly rotted compost, with two others, without manure, one lying between the two manured plots and the other adjacent to the one with horse manure, were kept fallow during the season, and frequently cultivated until the middle of July, and kept free from weeds. The water content of the soil on the several plots was determined at different times down to a depth of six feet.

On July 22, samples of soil were taken on the plot to which the horse manure had been applied and at the same time on the unmanured plots on either side of it and below are given the results of the determinations of the water content in each case:

Table showing the per cent. and amount of water, per cubic foot, in soil of manured and unmanured ground.

	A		B		C	
	UNMANURED.		MANURED.		UNMANURED.	
	Per cent. water.	Lbs. water per cu. ft.	Per cent. water.	Lbs. water per cu. ft.	Per cent. water.	Lbs. water per cu. ft.
1st foot..........	14.96	11.82	17.67	13.96	17.86	14.11
2d foot..........	16.34	15.14	19.37	17.94	18.92	17.53
3d foot.........	16.40	17.15	17.03	17.81	16.33	17.08
4th foot	12.62	13.40	12.00	12.75	12.94	13.74
5th foot	12.25	13 60	14.69	16.31	18.54	20.59
6th foot	19.52	21.68	18.01	20.00	20.59	22.87
Sums........	....	92.79	....	98.77	....	105.92

It will be seen that the figures show an increase in the total amount of water in each plot from A to C. This increase is due chiefly to the fact that the surface of the ground slopes in that direction more than does the water-table, the amount being the same as for the cultivated and uncultivated ground described in the last experiment. To compare these figures it is therefore necessary to combine those of plots A and C and compare the averages with those from plot B. When this is done we get the results given below:

Table showing the mean per cent. and total amount of water in manured and unmanured ground 77 days after plowing.

Depth.	A and C Unmanured.		B. Manured.		Difference.	
	Mean per ct. of water.	Lbs. of water per cu. ft.	Mean per ct. water.	Lbs. of water per cu. ft.	Per cent.	Lbs. per cu. ft.
1st foot........	16.41	12.97	17.67	13.96	+1.26	+ .99
2nd foot.........	17.63	16.34	19.37	17.94	+1.74	+1.60
3rd foot..	16.37	17.12	17.03	17.81	+ .66	+ .69
4th foot..........	12.78	13.57	12.00	12.75	— .78	— .82
5th foot..........	15.40	17.10	14.69	16.31	— .71	— .79
6th foot..........	20.06	22.28	18.01	20.00	—2.05	—2.28
Sums	... .	99.38	....	98.77	.. ..	— .61

It is evident from the above table that while the aggregate amount of water in the plots which are manured and unmanured is practically the same, the distribution of it in the ground is markedly different in the two cases; for while the upper three feet of the manured ground contain an average of 1.09 lbs. more water per cubic foot, the lower three feet contain 1.26 lbs. less than the unmanured ground.

On July 27, the water content of the plot to which cow manure had been applied and of the unmanured plot adjacent to it was determined, and the results appear below:

Table showing the per cent. and amount of water per cubic foot in manured and unmanured ground.

Depth.	C. Unmanured		D. Manured.		Difference.	
	Per cent. water.	Lbs. water per cu. ft.	Per cent. water.	Lbs. water per cu. ft.	Per cent. water.	Lbs. water per cu. ft.
1st foot...... ...	17.21	13.60	19.78	15.63	+2.57	+2.03
2d foot....... ...	17.30	16.02	19.88	18.41	+2 58	+2.40
3d foot...	16.02	16 76	17.77	18 59	+1.75	+1.83
4th foot.	16.43	17.45	15 79	16.77	—.64	—.68
5th foot..........	16.29	18.09	14.26	15.84	—2.03	—2.25
6th foot.	19.60	21.77	20.31	22.56	+.71	+.79
Sums	....	103.69	....	107.80	.. ..	+4.11

In this case, as in the former one, the surface of the ground slopes from C toward D more than the water-table so that, other things being equal, plot D should be wetter than plot C and so it is, on the whole, but the same general condition in the distribution of soil-water is shown here as there, for while the mean amount of water in the upper three feet of the manured ground is 6.25 lbs. more than on the unmanured ground that in the lower three feet is 2.14 lbs. less and yet, from its position, it should have been found wetter.

At a still later date, September 12, samples of soil were again taken from the four plots in composites of five as they had been in the former cases and the water content determined, the next table containing the results:

Per cent. of water.

	1st foot.	2nd foot.	3rd foot.	4th foot.	5th foot.	6th foot.
Plot A unmanured	10.84	14.09	12 86	9.44	8.89	15.54
Plot B manured..	13.75	16.41	15.67	12.96	11.49	15.61
Plot C unmanured	14.68	15.70	16.11	13.74	13.03	16.44
Plot D manured...	17 76	16.90	17.76	14.77	15.63	18.84

Pounds of water per cubic foot.

	1st foot.	2nd foot.	3rd foot.	4th foot.	5th foot.	6th foot.
Plot A, unmanured	8.56	13.05	13.45	10.03	9.87	17.26
Plot B, manured...	10.86	15.20	16.39	13.76	12.76	17.34
Plot C, unmanured	11.60	14.54	16.85	14.59	14.47	18.36
Plot D, manured...	14.03	15.65	18.58	15.69	17.36	20.82

On account of the unequal slope of the surface of the ground and of the water-table it is necessary, in order to compare results, to combine A and C and compare their average with B and also B and D to compare with C and when this is done we get the following:

	Average Pounds of Water Per Cubic Foot.					
	1st foot.	2d foot.	3d foot.	4th foot.	5th foot.	6th foot.
Plot B, manured	10.86	15.20	16.39	13.76	12.76	17.34
Plots A and C, unmanured...	10.08	13.80	15.15	12.31	12.17	17.76
Difference.	+ .78	+1.40	+1.24	+1.45	+ .59	— .42
Plots B and D, manured......	12.45	15.43	17.49	14.73	15.06	19.13
Plot C, unmanured...........	11.60	14.54	16.85	14.59	14.47	18.26
Difference............ ..	+ .85	+ .89	+ .64	+ .14	+ .59	+ .87

These figures show that in every case except one, and that the 6th foot, the unmanured ground is dryer than the manured, the average amount being as expressed below:

Average amount each foot of manured ground is wetter than the unmanured.

1st foot.	2nd foot.	3rd foot.	4th foot.	5th foot.	6th foot.
.82 lbs.	1.15 lbs.	.94 lbs.	.75 lbs.	.59 lbs.	.23 lbs.

On this date we find not simply a difference in the distribution of water in the upper six feet, but a difference in the total quantity as well, the mean difference in the total amount of water being 4.5 lbs. per each column six feet long and one foot square. It will be observed, however, that while the lower three feet of the unmanured ground

are dryer than those of the manured, contrary to what was observed before, still the difference is decidedly less than between the upper three feet, the difference in the two cases being

Upper three feet.	*Lower three feet.*
2.91 lbs.	1.57 lbs.

It is a well established fact that increasing the amount of humus in the soil increases its absolute water capacity and hence it was to be expected that the water content of the surface foot of the manured plots should, at first at least, be found greater than that of the unmanured ground. This was found to be the case but in addition the water content of the second and third feet was also greater. It appears, therefore, that the manure exerted an influence below the level at which it was placed and in some manner to increase the water content.

It is also well established that coarse litter, placed either upon the surface of soil or immediately below it, acts, for a time, to diminish the rate of surface evaporation and hence it was to be expected that the plot to which the horse manure had been applied should be found wetter than that to which no manure had been applied. This was found to be the case as late as May 20, when the third and fourth feet were 2.43 per cent. wetter than those of the unmanured plots each side though the surface two feet of the manured plot were .57 per cent. dryer, owing to the excessive drying of the soil which lay above the manure.

On July 22 and 27, however, when samples were again taken, as already mentioned, there was no marked difference in the total water content of the plots treated in the two ways, although the samples extended nearly to the water-table, but there was a striking difference in the distribution of it and the observed differences suggest that the manure, in both cases, was acting in some manner either to produce a translocation of water from the lower three feet toward the surface, or else downward into the standing water below; in other words, these observations suggest that in these cases farm-yard manure had the power of increasing the rate of capillary flow of water toward the surface from depths as great as six feet, or else of decreasing the water capacity of the lower three feet.

MANURED AND UNMANURED CORN GROUND.

It was shown in the Seventh Annual Report of this Station, page 134, that both firming the surface soil by rolling, and the wetting of it by rains or otherwise, may give rise to a translocation of soil-water extending to depths as great as four feet, and as the manure does tend to increase the water at the surface, by acting as a mulch and by increasing its water capacity, there is at least an apparent approach to a parallelism between them.

But if manures do really exert a protracted influence tending to draw water toward the surface from considerable depths, then the yield of dry matter per acre should be really larger without at the same time exhausting the soil moisture toward the surface to the same extent. We had this season four plots, two of which were fertilized with a top dressing of manure and alternating with them two others which were not so treated, and as the amount of dry matter produced under these two conditions was to be carefully determined, samples of soil, extending to the water-table, were taken on two of the manured plots and on the intermediate unmanured plot immediately after the corn was cut, to learn what their relative water contents might be. On these plots, as in those previously described, the surface of the ground and the water-table slope in one direction and as the plots were wider than in the cases cited samples were taken about 9 feet from the margin of each plot. Below are given the percentages of water the soil was found to contain:

Table Showing the per cent. of water in soil on manured and unmanured ground upon which corn had grown.

	PLOT I. MANURED.	PLOT II. UNMANURED.		PLOT III. MANURED.
	North side.	South side.	North side.	South side.
	Per cent.	Per cent.	Per cent.	Per cent.
Surface to 2 feet........ ..	12.00	13.40	12.65	12.78
2 to 4 feet..................	16.46	17.31	18.84	17.59
4 to 5 feet..................	15.18	15.84	19.44	18.30

If we now take the averages of Plots I and III and compare them with the averages from the two sides of Plot II we shall have:

	Unmanured.	Manured.	Difference.
	Per cent.	Per cent.	Per cent.
Surface to 2 ft.	13.03	12.39	.64
2 to 4 ft.	18.08	17 03	1.05
4 to 5 ft.	17.64	16.74	.90

Computing the absolute difference in the amout of water in the soil under the two conditions we get:

	Unmanured.		Manured.		Difference.
	Dry soil.	Water.	Dry soil.	Water.	
Surface to 2 ft.	146.59 lbs.	19.1 lbs.	146.59 lbs.	18.16 lbs.	.94 lbs.
2 ft. to 4 ft.	185.85 lbs.	33.6 lbs.	185.85 lbs.	31.65 lbs.	1.95 lbs.
4 ft. to 5 ft.	106.00 lbs.	18.7 lbs.	106.00 lbs.	17.74 lbs.	.96 lbs.
Sums		71.4 lbs.		67.55 lbs.	3.85 lbs.

In the following table are given the green and dry weights of the corn which grew upon the three plots under consideration together with the per cent. of water and corn contained at the time of cutting. The corn was cut Sept. 19 and was in good condition for shocking at the time:

	Plot I. Manured.	Plot II. Unmanured.	Plot III. Manured.
Weight of corn as cut	2597.1 lbs.	2174.2 lbs.	2741.9 lbs.
Weight of corn dry	891.32 lbs.	782.5 lbs.	894.41 lbs.
Per cent. of water	65.68	63.55	67.38

As the surface of the ground and that of the water table slope unequally from Plot I toward Plot III it is necessary to compare the average yield of Plots I and III with that of Plot II, and when this is done we get:

	PLOT I AND II. Manured.	PLOT II. Unmanured.	Difference.
Weight of corn as cut.....................	2669. 5 lbs.	2174.2 lbs.	495.3 lbs.
Weight of corn dry	8928.7 lbs.	782.5 lbs.	110.37 lbs.
Per cent. of water	66.53	63.55	2.98

These figures show that the mean yield of dry matter on the manured plots was 110.37 lbs. greater than that on the unmanured plot, and taking 301.49 lbs., the observed amount of water required for a pound of dry matter in corn we shall have:

110.37 lbs. × 301.49 = 33,275.5 lbs.

as the amount of water taken from the manured ground more than from the unmanured.

Now these plots were 35 feet wide and 120 feet long and contained, therefore, an area of 4,200 sq. ft., and we have shown that the unmanured soil contained at the time the corn was cut, 3.85 lbs. more water than the manured soil for each column 5 feet long and one square foot in area, and as these samples extended to fully saturated soil, this may be regarded as the true difference in the amount of water as nearly as the method used was capable of revealing it. The amount of water, therefore, which observation shows the increased yield to have withdrawn from the soil is

3.85 lbs. × 4,200 = 16,170 lbs.

but the amount of water required, as computed from the observed difference in the amount of dry matter produced and the observed amount of water required for a pound of dry matter in corn, is 33,275.5 lbs., and hence

33,275.5 lbs. — 16,170 lbs. = 17,105.5 lbs.

as the amount of water demanded by the corn which the observed difference in the amounts of water in the soil does not account for. If we divide the amount of water demanded by the plot of manured ground more than was required by the unmanured by the area in square feet we get

$$\frac{33,275.5}{4,200} = 7.92 \text{ lbs.}$$

as the difference in the amount of water which should have been found per column of soil 1 sq. ft. in section. But the observed difference was only 3.85 lbs. and hence there remains an unaccounted for amount of

$$7.92 - 3.85 = 4.07 \text{ lbs.}$$

which must have been brought up from the supply of permanent water in the ground unless, first, a pound of water on manured ground yields more dry matter than on unmanured ground or second, unless the evaporation from the surface of the manured ground was less than that from the unmanured. Now if the excess of water demanded by the manured ground was obtained through a diminished surface evaporation simply, then the observed differences on the fallow plots at the close of the growing season should be found approximately equal to the amount demanded. The observed amount was 4.5 lbs. per square ft. while the amount demanded was 7.92 lbs. a quantity nearly twice as great and too large to be attributed to errors of observation; unless, therefore, it is true that water is used by corn with much greater efficiency on manured ground, it follows that the manure has effected the drawing of water from greater depths by the corn, and if this was not done by forcing the roots to penetrate the soil more deeply the rise of water must have been a third case of translocation.

While, therefore, the case stands confessedly as one lacking complete demonstration, the evidence in favor of the view that farm-yard manure increases the capillary flow of water toward the surface and thus supplies to crops both water and minerals held in solution by it which would otherwise be unavailable, is both cumulative and, thus far, positive. I have other experiments under way which appear now to confirm these results.

The data which have been presented regarding the influence of cultivating soil suggests that here also a similar influence is exerted, but the evidence is less in quantity and not as strong.

INFLUENCE OF FALLOWING GROUND ON THE WATER CONTENT OF THE SOIL.

During two seasons in succession we have observed, on the Station farm, that not only was the water-content of a fallow soil greater at the end of the growing season than that of adjacent and similar soil upon which crops had grown, as was to be expected, but that there was still a marked difference the following spring, at seeding time, after all the fall, winter and spring rains had been received, and this too in localities where standing water in the ground existed at distances varying with the time of year, from only 5 ft. to 8.5 ft. from the surface. We have now followed the changes in the water content of fallow soil through a succeeding summer during which it has produced a heavy crop, and find that at the time when the crop had been matured and removed the fallow ground was still wetter, in a marked degree, than was adjacent and similar soil which the preceding year had not been fallow.

In Fig. 2, page 92, plots 1 and 3 were fallow during the summer of 1890 while plot 2 had produced a crop of corn. This season the three plots produced oats on the east half and barley on the west, and at the time the grain was cut two samples of soil were taken in one-foot sections from each of the eighteen small plots, extending to a depth of four feet, at the places shown by the dots in the cut. The following table expresses the results of these determinations:

Table showing the per cent. of water in soils which the preceding year had been respectively fallow and not fallow.

Depth of Sample.	Oats.						Barley.					
	Plots 1 and 3. Fallow.			Plot 2. Not Fallow.			Plots 1 and 3. Fallow.			Plot 2. Not Fallow.		
	a	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*	*a*	*b*	*c*
1 foot.... ..	7.15	7.68	8.50	6.19	4.65	3.68	11.50	11.40	12.29	9.63	7.47	10.38
2 foot	11.03	12.14	13.13	5.80	5.86	5.03	15.40	14.22	15.10	12.37	11.81	13.80
3 foot	8.96	10.20	11.22	8.96	9.82	10.86	11.46	13 90	14.41	11.02	11.76	11.01
4 foot........	9.26	9.17	8.89	8.91	8.51	8.39	15.16	14.12	13.78	12.79	11.77	10.68

In this table, columns a, in each case, represent the per cent. of water in soil where the grain had been simply drilled in, columns b, where the ground was rolled after drilling, and columns c, where the ground was rolled and then harrowed after drilling. When the percentages in columns a, b and c, on the fallow ground, are compared foot by foot with a, b and c of the not fallow ground, from the portions producing both oats and barley, it will be observed that there is but a single exception in the 24 cases to the soil from the fallow ground being wetter than the not fallow ground. Because the water-table and the surface of the ground slope unequally from 1 toward 3, Fig. 2, the observed per cents. of water in plots 1 and 3 are averaged to compare with those of plot 2 in the table. In the following table the condition of the soil in the spring is given, together with the pounds of water per cubic foot at harvest time, the samples taken from the soil receiving the three kinds of treatment having been combined, in each case, and the average used.

Table showing mean dry weight of soil per cubic foot and of water per cubic foot in fallow and not fallow ground in spring and at harvest.

Depth of sample.	Mean dry weight of soil per cu. ft.	In Spring.				At Harvest.			
		Plots 1 and 3.		*Plot 2.*		*Oats.*		*Barley.*	
		Fallow.		Not fallow.		Fallow.	Not fallow.	Fallow.	Not fallow.
	Lbs.	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1 ft........	77.25	19.43	15.01	16.61	12.83	6.01	3.74	9.06	7.08
2 ft.......	79.79	20.55	16.40	17.76	14.17	9.65	4.45	11.90	10.10
3 ft.......	94.13	18.56	17.47	16.09	15.15	9.54	9.30	12.48	10.60
4 ft.......	98.07	17.78	17.44	15.11	14.82	8.93	8.43	14.07	11.52
Sums....	....	....	66.32	....	56.97	34.13	25.92	47.51	39.30

It will be seen from this table that the difference in the amount of water in the soil at harvest is only 1.14 lbs. less than it was in the spring, and yet the amount of dry matter produced on the fallow ground was greater than that produced on the not-fallow ground, so that other things be-

ing equal the fallow ground ought to have been found the dryer at harvest by the difference in the amount of water required by the crops in the two cases. If the consumption of water was proportional to the amount of dry matter produced and at the observed rate given on page 126, the oat ground which had been fallow should have dried 3.09 lbs. more than that not fallow, but it did dry only 1.14 lbs. more, and this shows an advantage of 1.95 lbs. of water for each column of soil one square foot in section and four feet long, in favor of the fallow ground. In the case of the barley the fallow ground should have dried 13.08 lbs. more than that not fallow, but like the oat ground it did dry only 1.14 lbs. more, so that there is an apparent advantage of 11.94 lbs. of water per sq. ft. extending to a depth of four feet.

That the difference in the per cent. of water in the soil of the fallow and not fallow plots is not wholly due to local peculiarities existing before the experiment began is proven by the relative water-contents at times before the fallowing influences could have had any effect. In the table below are given the mean per cents. of water contained in the soil of the three plots as determined from samples taken May 22, June 11 and June 17, 1889.

Table showing the mean per cent. of water in plots 1, 2 and 3 before the fallowing experiments began.

Depths.	Plot 1.	Plot 2.	Plot 3.	Av. plots 1 and 3.
	Per cent.	Per cent.	Per cent.	Per cent.
Surface to 12 in.	23.04	21.49	24.23	23.63
12 in. to 18 in.	18.69	18.57	20.87	19.78
24 in. to 30 in.	17.45	18.13	18.68	18.06
36 in. to 42 in.	15.46	17.48	15.54	15.50
48 in to 52 in.	15.62	18.91	22.45	19.03
Averages	18.05	18.92	20.35	18.20

These figures show that there is a slight natural tendency of Plot 2 to be dryer than the average of Plots 1 and 3, but that the difference is much smaller than that observed after the effects of fallowing have been added.

THE AMOUNT OF WATER REQUIRED TO PRODUCE A POUND OF BARLEY, OATS AND CORN IN WISCONSIN.

There is no food-stuff, either for animals or for plants, more important in its functions than water for, besides being an essential component of the tissues in both types of life, it is the one medium by which all other foods are transported to their destination in the organism. The raising of plants, like the raising of animals, is specifically *a feeding* enterprise and just as the most remunerative animal feeding demands that the right amount of water be supplied when it is needed so do the largest returns in plant husbandry demand that there be neither too much nor too little water. In supplying the wants of the animal, in this particular, we may leave the exact amount to be determined by the appetite of the individual, while, ordinarily, the supply on hand, is, at all times, indefinitely more than is needed and hence it is not practically very important that we should know exactly how much water our animals require. With plants, however, the problem is very different. Here the individuals are fixed in the soil where the quantity of water may be either too large or too small, and where momentary changes in the amount, such as are practicable with animals, are impossible. Neither can we depend, as with the animal, upon the plant to decide the amount of water which should be presented to it from week to week. In plant feeding, therefore, we need to know not only the depth of soil which may contribute water to the crop and the best amount that soil should contain but in addition how much that crop is likely to demand, for only then are we in a position to know whether to husband the supply or to reduce the amount.

In the Sixth Annual Report, page 191, are given some of the results of a study of this problem carried out by Hellriegel, in Prussia, but the climate of that country is very different from our own, so that the rate of evaporation is likely not to be the same, and the results not to be strictly true with us. During the past season we carried on observations to determine the amount of water required to pro-

duce a pound of dry matter of corn, oats and barley, including surface evaporation from the soil upon which the crops grew.

PLAN OF THE EXPERIMENT.

The aim in this work has been to make the conditions as nearly as possible those which exist in actual field culture and to do this the barley, oats and corn were grown in 50 gallon barrels standing with their tops flush with the top of the ground, in pits sunk in fields of the respective grains as shown in Fig. 4. The barrels were filled with soil

FIG. 4. Showing the method of measuring the amount of water required to produce a pound of dry matter in barley.

taken from the place and in each case the experiment was in duplicate. In all cases the barrels received the natural rainfall and in addition watering was resorted to from time to time as the cases required, an effort being made to maintain the barrels at nearly constant weights. No effort was made to check *surface* evaporation from the soil, but the barrels being painted and standing in the ground as shown in the cut, the loss of water through the *side* was certainly not large. With the oats and barley the surface soil was not disturbed after the seeding, but in the case of the corn the ground was frequently stirred to correspond with the field cultivation.

In the table which follows are given the observed amounts of dry matter produced and the quantities of water which disappeared in their production, together with the computed yield per acre, and the amount of water for the same expressed in tons and in inches of rainfall:

Table showing the amount of water required for a pound of dry matter in Wisconsin for oats, barley and corn.

		Lbs. of water used.	Lbs. of dry matter produced.	Lbs. of water per lb. of dry matter.		C'mput'd yield per acre.	Computed amount of water.	
					Mean.	Lbs.	In tons per acre.	In inches.
Barley. ...	1	158.3	.3966	399.14	401.74			
Barley.....	2	141.03	.3488	404.33		7441	1494.67	13.19
Oats.......	1	224.25	.4405	509.31	501.47			
Oats.......	2	220.7	.4471	493.63		8861	2221.76	19.60
Corn	1	300.45	1.0152	295.95	301.49			
Corn	2	298.65	.9727	307.03		19845	2991.53	26.39

It will be seen from this table that the results obtained from the two barrels, in each case, are fair duplicates both as regards the amount of dry matter produced and the quantity of water consumed; the yields, however, are large and in the case of the corn excessively so. In the cases of barley and oats, so far as could be observed, the stand of grain on the ground in the barrels and the growth of it throughout the season was perfectly normal, but the yield of dry matter per acre, in the field in which the barrels

stood, was 6,083 lbs. of oats and 4,157 lbs. of barley per acre as the average deduced from plots 1, 2 and 3, Fig. 2, between which the barrels stood and with the soil of which they were filled, while the yield from the barrels was at the rate of 8,861 lbs. of oats and 7,441 lbs. of barley per acre as given in the table.

In the case of the corn the conditions and the growth as well were quite different in the barrels from what they were in the field in which they stood. Each barrel matured four stalks of corn on an area of 2.1817 sq. ft., but in the field there were four stalks to each 9⅓ sq. ft., which is more than four times the area; this being true the amount of evaporation from the ground itself as compared with that which took place through the growing corn must have been relatively larger in the field than in the barrels, and this must tend to make the amount of water required for a pound of dry matter as indicated by the experiment too low for the conditions in the field. Early in the season the growth of the corn in the barrels was more vigorous than that surrounding it in the field, but after it had obtained a height of 2.5 feet it became evident from the lighter color that the corn in the barrels was falling behind that in the field. Watering the corn with liquid farm-yard manure did not appreciably improve the color, and it was not until the pollen of the field corn was nearly all shed that the real difficulty was ascertained. At this time the corn in the barrels began to wilt in spite of the fact that the barrels were as heavy as they were in the spring when the corn was planted. An examination of the soil revealed the fact that nearly all the water had been withdrawn from the lower half of the barrel and that the corn was really suffering for water in spite of the fact that the surface foot contained an abundance of it. After wetting the lower soil the corn improved in color, but only two stalks in each barrel produced ears, and these were smaller than the average in the field. Just how this deficiency of water has influenced the amount of water for a pound of dry matter it is impossible to say. It is very suggestive as to the great importance of the right amount of soil-water at all times that, in spite of

the deficiency of water for a time in the barrels, the actual yield of dry matter was 19,845 lbs. per acre while that of the field surrounding it was only 8,190.5 lbs.

FIELD EXPERIMENTS.

In 1890 and again in 1891 the water content of soil upon which corn was grown was determined at the time of planting and again when the corn was cut to ascertain the amount of water required for a pound of dry matter as indicated by the diminished soil-moisture and the rains which fell between the planting and harvesting of the corn.

Litch Dent, a local form of Pride of the North, was used both years, and in 1890 the corn was grown in six plots, each 48 feet long and 14 feet wide. The rows were 3.5 feet apart with the corn planted in hills at a distance of 16 inches in the row and thinned after coming up to two stalks in a hill. At maturity the whole corn of each plot was dried to determine the amount of dry matter produced. Samples of soil were taken in foot sections to a depth of four feet just as the corn was coming up and again when it was cut and the water content determined. Half of the corn was grown upon plot 2, Fig. 2, p. 92, and half upon plot 4. Below are given the water content of the soil in two groups of plots at the time of planting and harvesting and the changes which occurred in the interval. Each per cent. is an average of six samples, two from each plot:

Table showing the changes in the water content of soil upon which corn had been growing in 1890.

Dry weight of soil.		1st foot. 77.25 lbs. per cu. ft.		2nd foot. 79.79 lbs. per cu. ft.		3rd foot. 94.13 lbs. per cu. foot.		4th foot. 98.97 lbs. per cu. ft.	
		Per ct.	Lbs.	Per ct.	Lbs.	Per ct.	Lbs.	Per ct.	Lbs.
Plot 2.	June 7....	22.66	17.50	19.77	15.77	18.16	17.09	19.16	18.79
	Sept. 16...	15.75	12.17	11.80	9.42	9.91	9.33	10.77	10.56
	Diff.	6.91	5.33	7.97	6.35	8.25	7.76	8.39	8.23
Plot 4.	June 7....	24.93	19.26	24.32	19.40	20.08	18.90	19.37	19.00
	Sept. 16...	18.43	14.24	15.03	11.99	12.62	11.88	9.80	9.61
	Diff..... .	6.50	5.02	9.29	7.41	7.46	7.02	9.57	9.39

From this table it appears that each column of soil 1 sq. ft. in section and 4 feet long, lost water as follows:

	Plot 2.	Plot 4.
Change in water content....	27.67 lbs.	28.84 lbs.
Rainfall June 7-Sept. 16.........	64.72 lbs.	64.72 lbs.
Total loss	92.39 lbs.	93.56 lbs.

The amount of dry matter produced on each of the plots is given below:

	Plot 2.		Plot 4.
I.................	139.48 lbs.	I.....	140.43 lbs.
II.....	150.90 lbs.	II......................	149.41 lbs.
III...........	159.80 lbs.	III......................	165.52 lbs.
Sums........	450.18 lbs.	....	455.36 lbs.
Total area of plots.......	2,016 sq. ft.	....	2,016 sq. ft.
Yield of dry matter......	.2233 lbs per sq ft.	....	.2259 lbs. per sq. ft.
Yield of dry matter......	9,727 lbs. per acre.	... .	9,840 lbs. per acre.

Were it admissible to assume that the percolation of rain water below the surface four feet had been exactly equalled by the capillary rise of water into them from below, it would follow, from the observed losses of water and yields of dry matter per square foot, that the amounts of water required for a pound of corn were 413.7 lbs. for plot 2, and 414.2 lbs. for plot 4.

The result of a similar study with the same variety of corn in 1891, gave in one case 309 lbs. of water for 1 lb. of dry matter on ground which was manured, and 333 lbs. on ground not manured. The amount of percolation during the growing season in 1890, was certainly greater than during 1891, and this may or may not be an explanation of the difference in the amounts of water required for a pound of dry matter in the two seasons.

In the case of the oats grown in the field the amount of water required for a pound of dry matter on ground which

the year before had been fallow was 519 lbs., and on ground which had not been fallow it was 534 lbs.

Again, the barley of the field showed only one pound of dry matter for 537 lbs. of water lost from the soil on the the ground which had been fallow and 719 lbs. on the ground which had not been fallow. All these statements are made on the assumption that there had been no percolation deeper than four feet and no addition of water to the upper four feet by capillary action from below, neither of which conditions are likely to have been true. The facts which have been given regarding the rise of water in natural field soils make it appear quite probable that the rise of water into the upper four feet from below by capillarity really exceeded the total percolation during the growing season in all the field cases cited unless possibly the two for 1890 should be excepted.

If we count the rainfall, during the growing season, and the difference between the amounts of water in the soil at the time of planting and at harvest, in the several field cases, as the amount used by the crops, including surface evaporation, and then compare these amounts per square foot with those added to the several barrels we shall get the results given below:

Pounds of water consumed per sq. ft.

OATS IN BARRELS.		OATS IN FIELD.		Mean Difference.
No. 1.	No. 2.	Fallow, 1890.	Not fallow.	
101.16 lbs.	102.79 lbs.	73.55 lbs.	72.41 lbs.	28.99 lbs.
BARLEY IN BARRELS.		BARLEY IN FIELD.		Mean Difference.
No. 1.	No. 2.	Fallow, 1890.	Not fallow.	
77.71 lbs.	80.51 lbs.	59.22 lbs.	58.08 lbs.	20.46 lbs.
CORN IN BARRELS.		CORN IN FIELD.		Mean Difference.
No. 1.	No. 2.	Manured.	Unmanured.	
136.89 lbs.	137.71 lbs.	65.24 lbs.	62.35 lbs.	73.50 lbs.

From these figures it appears that while more water was consumed in the field per pound of dry matter produced than in the barrels, the amount of water used per square foot in the barrels was much greater than the measured losses in the field and these facts are suggestive, though of course not at all demonstrative, that when a sufficient quantity of water is at all times maintained, its effectiveness is increased and that this is one reason, and possibly the chief one, why the yield per acre being greater, the number of pounds required for a pound of dry matter in the barrels has in every case been smaller than that indicated in the field.

VERTICAL EXTENT OF ROOT FEEDING.

During the summer of 1889 an effort was made to ascertain the depth to which corn roots extract moisture from the soil by growing it between fallow plots and noting the changes which occurred in the level of standing water in the soil beneath both the fallow ground and that upon which corn was growing The results of that study indicated that the water did fall more rapidly under the corn than it did beneath the fallow surface; but as the warped condition of the water-table in 1889, as shown in Fig. 2 p. 159, 1890, might have been due to drainage peculiarities the experiment was repeated the succeeding year by growing corn upon the plots which in 1889 were fallow and leaving those upon which corn had been grown free from weeds and without a crop.

The changes in level which occurred in the surface of standing water in the ground were measured by means of a micrometer constructed for the purpose. The positions of the wells at which the changes in the water level were noted are shown in Fig 2. p. 92.

In the table which follows, the changes which occurred in the water-surface during the seasons of 1889 and 1890 are given, the numbers expressing the distances the water was above a common datum plane at the time stated:

Table showing changes in the water surface under fallow and not fallow plots, during the growing seasons of 1889 *and* 1890.

Date.	Changes During the Summer of 1889.						
	Corn.	*Fallow.*	*Corn.*	*Fallow.*	*Corn.*	*Fallow.*	*Corn.*
	Well 1.	Well 2.	Well 3.	Well 4.	Well 5.	Well 6.	Well 7.
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
May 27	5.69	5.5966	5.48	5.424	5.3625	5.331	5.228
June 20	5.52	5.4191	5.33	5.262	5.210	5.191	5.043
July 1	5.4393	5.3476	5.2144	5.168	5.0567	5.047	4.8782
July 10	5.292	5.1989	5.042	5.016	4.9393	4.864	4.6732
August 1	5.03	4.9316	4.787	4,7567	4.6488	4.575	4.433
August 24	4.7485	4.6442	4.5187	4.456	4.370	4.257	4.094
September 26	4.429	4.3572	4.2615	4.1853	4.0732	3.978	3.849
October 29	3.975	3.9137	3.834	3.766	3.649	3.568	3.445

Date.	Changes During the Summer of 1890.						
	Fallow.	*Corn.*	*Fallow.*	*Corn.*	*Fallow.*	*Corn.*	*Fallow.*
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
May 29	5.599	5.590	5.491	5.4243	5.406	5.3543	5.148
June 19	6.504	6.486	6.346	6.2423	6.168	6.0973	5.855
July 2	6.3646	6.2813	6.1218	5.9963	5.9058	5.8195	5.5988
July 10	5.9954	5.905	5.751	5.6366	5.5592	5.4821	5.2456
Aug. 1	5.418	5.335	5.185	5.1043	5.057	5.0033	4.760
Aug. 23	5.069	5.001	4.890	4.8053	4.737	4.6553	4.493
Sept. 27	4.838	4.779	4.678	4.6083	4.545	4.4703	4.317
Oct. 7	4.786	4.731	4.650	4.5773	4.501	4.4453	4.308

If we determine the mean fall of the water on the fallow ground and compare this with the mean fall on ground bearing corn we shall get the results here stated:

Table showing mean fall of water on corn ground compared with that on the fallow ground.

1889.				1890.			
Date.	Corn.	Fallow.	Difference.	Date.	Corn.	Fallow.	Difference.
	Inches.	Inches.	Inches.		Inches.	Inches.	Inches.
May 27 to June 20.	1.973	1.918	.055	June 19 to July 2..	2.914	2.646	.268
.. July 1.	3.516	3.156	.360	.. July 10 .	7.248	6.965	.283
.. July 10.	5.442	5.091	.351	.. Aug. 1..	13.532	13.359	.173
.. Aug. 1.	8.585	8.353	.232	.. Aug. 28..	17.456	17.052	.404
.. Aug. 24.	12.088	11.978	.110	.. Sept. 27 .	19.872	19.485	.387
.. Sept. 26.	15.443	15.324	.119	.. Oct. 7..	20.288	19.884	.404
.. Oct. 29.	20.573	20.416	.157				

It is here seen that during the whole of the growing season of 1889, the mean fall of the water under the corn was greater than it was under the fallow ground, and that the same thing is true in 1890 when the conditions are reversed. It would appear, therefore, so far as two concordant trials can settle a complex problem of this character, that the corn did exert a measurable influence in depressing the surface of standing water in the ground. The data given in the first table show that the rains after May 29, 1890, raised the surface of standing water in the ground about one foot, placing it about this distance above the level of the water on the same date in 1889, and that throughout the season this difference was maintained. Associated with this higher level of the water-surface in 1890, the second table shows a larger difference in the mean fall of the ground water, as should be expected if vertical distance is a factor in the problem. On September 26, at the time the last of the corn was cut in 1889, the water stood 7.77 feet below the surface of the ground at Well 1, under the corn, as shown in Fig. 2, page 159, 1890; in 1890 the water stood on September 27, when the corn was cut, 6.9 feet below the surface of the ground on plot 2.

When the facts here presented are viewed in conjunction with those on page 104, showing the depth to which fallow ground is dried during the summer, it may be regarded safe to conclude that under the conditions of good cultivation corn may draw, in considerable quantities, upon soil water existing at depths greater than seven feet below the surface.

EXPERIMENTS WITH THE POTATO

E. S. GOFF.

1. *A test of varieties.*

Experience leads us to place less and less confidence in the value of variety tests with the potato. That a variety proves most productive at our Station one season is no sure indication that it will do so the next. A test probably does, however, usually permit the separation of the more vigorous from the more feeble varieties, and thus far is of value.

Our trial list the past season included 59 varieties. About midsummer, the foliage of our potatoes was quite seriously attacked with blight, which affected the varieties in different degrees. It is not thought best to publish the yields of our entire list, as has generally been done in past reports, but to limit our report to the ten most productive varieties. It should not be assumed that the precise order of their productiveness will be maintained in other trials, but only that these ten are vigorous, prolific varieties that suffer less from blight than many others.

Our potatoes were grown on fall-plowed sod, on a fertile light loam, well prepared in spring with the disk harrow. Cuttings of two eyes each, were planted April 30 and May 1, 18 inches apart, in furrows 38 inches apart, and three inches deep, one row 45 feet long of each variety. The yields and date of dying of the tops of the ten most productive varieties were as follows:

Table showing yield and date when tops were dead, of the ten most productive varieties.

Variety.	Yield.		Tops dead.
	Merchantable.	Small.	
	Lbs.	Lbs.	
Burpee's Superior	47¾	6¾	September 28 (killed by frost).
Maine Champion	45¼	14½	September 28 (killed by frost).
Pride of the West	38¼	19¾	September 22.
Bill Nye	38	6½	September 28 (killed by frost).
Boley's Northern Spy	35½	5¼	September 9.
Delaware	34¼	9¼	September 24.
Harris No. 1	34¼	8	September 17.
Duplex	34	7¼	September 9.
Dandy	32¼	3¼	September 28 (killed by frost).
Seneca Red Jacket	31½	7½	September 13.

HILL VERSUS DRILL PLANTING.

Another trial with hill as compared with drill planting adds weight to the conclusion of last year, that "no loss of yield followed planting in hills." The trial here reported included 68 rows 142 feet long and three feet apart, of which each alternate row was planted with single two-eye cuttings of Rose Seedling potato, 18 inches apart, and the remaining rows with two cuttings in a hill three feet apart. Other conditions were as noted for the variety test. The 34 drilled rows yielded 1,936½ pounds of merchantable and 343 pounds of small potatoes, against 1,922¼ pounds of merchantable, and 223¾ pounds of small potatoes from the 34 rows of hills. These figures are as near duplicates as could be expected in a planting of this area.

SHALL WE CUT OFF THE "SEED-ENDS" OF POTATOES?

In 1889, a comparative trial of potatoes planted whole, with others from which a small portion had been cut off from the distal, or "seed" end seemed to show that the removal of the so-called seed-end is detrimental to yield.

Another trial carried out the past season furnishes added evidence in the same direction.

In this trial it was assumed that if the removal of the seed-end tends to reduce the crop, its effect would be more conspicuous where the tubers were planted without cutting (except to remove the seed-ends) than where they were further cut; but that if the effect of removing the seed-end is marked, it should still be manifest in the latter case. Accordingly, three conditions of seed were planted as follows:

1st. Four rows planted with rather small merchantable tubers were alternated with four rows of similar tubers from which the seed-end had been removed.

2nd. Six rows planted with medium tubers cut lengthwise were alternated with six other rows of similar seed cut in the same way, except that the seed-end was removed previous to the cutting.

3rd. Twelve rows planted with large tubers cut to two eyes, were alternated with twelve rows planted with similar seed except that the tubers had the seed-end removed previous to the cutting.

The weight of the seed planted was taken in every case.

The yields were as follows:

Table showing results of trials in removing seed-ends from potatoes.

	SEED-END NOT REMOVED.			SEED-END REMOVED.				
	Weight of seed.	*Yield of—* Merchantable.	*Yield of—* Small.	Weight of seed.	*Yield of—* Merchantable.	*Yield of—* Small.	Gain by retaining seed-ends. (Merchantable.)	Per cent.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
1st series.								
Seed planted whole..	71½	285½	155½	69	236	159¼	47	22.43
2nd series.								
Seed cut lengthwise..	85	504	208¾	77	495	205¼	1	......
3rd series.								
Seed cut to two eyes..	80	1,023¾	329½	84½	1,013	314½	24.5	2.6

It appears that the difference was marked where whole seed was used, but less marked where the seed was cut. In no case, in this or in previous experiments, conducted by the writer, has the removal of the seed-end shown an advantage in yield.

TREATMENT FOR THE POTATO BLIGHT.

As noted elsewhere, a series of experiments in the treatment of plant diseases devised by Mr. B. T. Galloway of the Department of Agriculture at Washington, was carried out under the direction of the writer on the farm of Mr. A. L. Hatch, of Ithaca in this state. One of these experiments consisted of a treatment for the potato rot fungus, *Phytophthora infestans* De By. A report of this experiment has already been published in the Journal of Micology, Vol. VII, p. 23, and an abstract of the same in the report of the secretary of agriculture, 1890, p. 400.

The fungicide used was the Bordeaux mixture, prepared by slacking 6 pounds of lime in one vessel, and dissolving 4 pounds of copper sulphate in another, uniting the contents of the two vessels on the cooling of the lime, and diluting the whole with water to 22 gallons. As the copper sulphate dissolves rather slowly, it is well to place it in about 6 gallons of hot water the day before the mixture is to be used.

The plot selected for the experiment included about half an acre of ground nearly in the form of a square, and was planted with snowflake potatoes May 31, the seed being placed in hills 3½ feet apart each way.

Five rows extending through the center of the plot in each direction were staked off as a check area, the four corner plots thus separated being subjected to the treatments. The S. W. plot was treated with the Bordeaux mixture at its full strength; for the N. E. plot the mixture was diluted about one-fourth, for the S. E. plot about one-third, and for the N. W. plot about one-half.

The first treatment was given July 3d, at which time the plants were 3 to 15 inches high, and apparently entirely

healthy. Other treatments were given July 14 and 25, August 6 and 19, and September 2.

More or less of the mixture was visible upon the tops at all times after the first spraying, until the crop was harvested. At the time of the fifth spraying, (August 19) it was evident that the treatment was proving beneficial, as the foliage of the check rows was turning yellow, and, in spots, becoming brown and apparently dying, while that of the treated portions was still fresh and green. At the last spraying, (September 2) the effect of the treatment was still more marked, the tops in the check rows being mostly dead or severely blighted, while very little of the blight was visible on the treated plants.

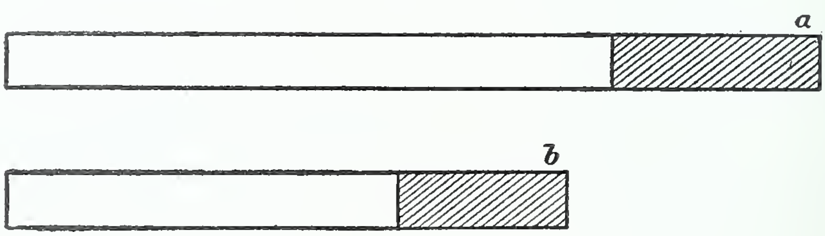
During my visit to Mr. Hatch's place in the latter part of September, the check rows were conspicuous by their brown and dry appearance at a distance of several rods from the field, while the vines in the treated areas were still, for the most part, green and growing. A frost occurred September 28 which destroyed most of the surviving foliage. Oct. 9 to 15, the potatoes in the various plots were dug, assorted, counted, measured and weighed. The numerical data appear in the following table:

Table showing results of experiments in treating potato tops to prevent blight.

Plot.	No. of Hills.	Merchantable Yield.		Total Yield.		Yield Calculated to a Uniform Number of Hills.			
						Merchantable Yield.		*Total Yield.*	
		Number.	Weight in pounds	Number.	Weight in pounds	Number.	Weight in pounds	Number.	Weight in pounds
N. E. corner...	321	2,255	835	6,815	1,133	2,669	988	8,068	1,310
N. W. corner..	287	2,530	871	6,455	1,102	3,350	1,049	8,547	1,459
S. E. corner....	340	2,176	903	7,462	1,320	2,432	1,009	8,340	1,475
S. W. corner...	343	3,075	1,127	6,905	1,367	3,407	1,249	7,650	1,514
Check	380	2,125	698	6,200	1,000	2,125	698	6,200	1,000

The unequal number of hills in the different plots arose from two causes, viz., the whole area was not quite regular in outline, and as the ground was a little sloping, the heavy June rains washed out some hills in places. The numbers recorded in the table represent the hills that matured their crop, as determined by counting before the potatoes were dug.

As the check rows traversed the whole planted area in both directions, we are justified in assuming that they represented an average of the whole plot, so far as the conditions of soil and culture were concerned, and that any difference in the yield of these rows, and that of the average of the four treated plots, when calculated to a given number of hills, was due to the treatment. In other words, had each of the four treated plots contained the same number of hills as the check rows, the aggregate yield from them would have been, without treatment, approximately four times as much as that from the check rows. Considering the yield of merchantable potatoes then, the four treated plots would have yielded without the treatment 4x698 or 2,792 lbs., whereas they actually yielded 4,295 lbs., or an increase, presumably due to the treatment, of 1,503 lbs., a fraction over 25 bushels. The effect of the treatment more readily appears from the following graphic diagram, in which *a* represents the yield of the treated portion, and *b* the untreated. The white portion at the left represents the merchantable and the lined portion at the right, the small potatoes:



From the figures, it would appear that the applications to the S. W. plot, in which the fungicide was used at its full strength, were most effectual, and that for the potato, the Bordeaux mixture should not be diluted.

The cost of the treatment was approximately as follows:

69 lbs. copper sulphate at 9 cts	$6.21
24 hours labor ac 15 cts	3.60
Labor in preparing mixture	.50
Total	$10.31

from which it appears that the treatment, though made with a small hand force pump, and in the most thorough manner, was more than compensated for by the increased yield secured.

It should be added that none of the potatoes were decayed at the time of digging, and that there were no indications that the blight, which so injuriously affected the foliage of potatoes the past season on the check rows of our experimental plot, and throughout southern Wisconsin, was connected in any way with the potato rot fungus, *Phytopthora infestans*. But whatever the affecting disease was, it is evident that the treatment proved a remedy for it.

Mr. Hatch states that the Colorado potato beetle did not attack the potato plants in the treated plots, an additional point of some value in favor of the treatment.

STRAWBERRY AND RASPBERRY TESTS.

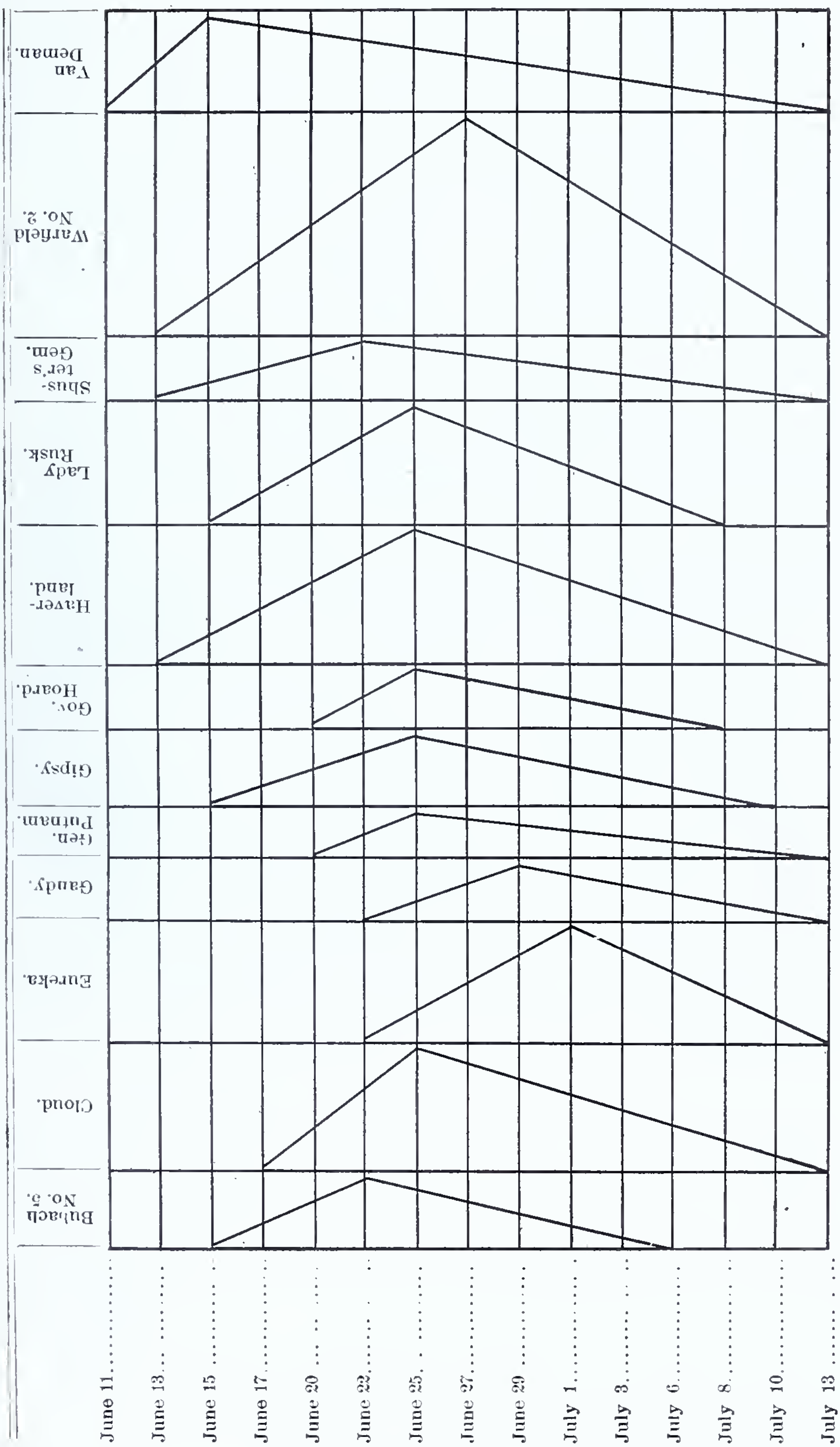
E. S. GOFF.

Strawberry.— The tests reported are of a single matted row of each variety, twenty-four feet long. With the exception of General Putnam, Shuster's Gem and Van Deman, the plants were set in the spring of 1889, and are the same as those reported upon last season. The plants of General Putnam were set in the fall of 1889, and those of the other two named in the spring of 1890. All received good garden culture, and were well protected through the winter.

During the fruiting season, the ripe berries were picked once in two or three days, and the yields noted in quarts and fractions. The diagram on the opposite page shows the comparative productiveness of the different varieties, and the dates of the first, last and largest picking. The productiveness of the different varieties is indicated by the width of the triangle, the names being printed at the top. The dates of the different pickings are indicated at the left, and the greatest width of the triangle for each variety is placed on the date at which the largest picking was secured.

It appears that the Warfield No. 2 was not only most productive, but it continued in bearing as long as any other, with the single exception of the Van Deman, which gave one picking before any other. The latest variety was the Eureka, which gave its first picking June 22, and its largest picking July 1.

The Monmouth, of which plants were received in 1889 from the J. T. Lovett Co., and the Clingto and Clara from the Cleveland Nursery Company the same year, were also tested, but failed to show any commendable qualities, as compared with the many superior sorts.


Van Deman.
Warfield No. 2.
Shuster's Gem.
Lady Rusk.
Haverland.
Gov. Hoard.
Gipsy.
Gen. Putnam.
Gandy.
Eureka.
Cloud.
Bubach No. 5.
June 11
June 13
June 15
June 17
June 20
June 22
June 25
June 27
June 29
July 1
July 3
July 6
July 8
July 10
July 13

Among the newer varieties, the Van Deman, of which plants were received from Jacob C. Bauer, Judsonia, Ark., has much to commend it as a family strawberry. It continued in bearing an entire month, the fruit was of good quality and the flowers are perfect. Its earliness, and the fact that it ripens the bulk of its crop so early, will commend it highly for market. The fruit is sufficiently firm to endure carriage fairly well.

Shuster's Gem yielded very fine berries, but the quality was inferior. General Putnam has points of value as a family berry, but the fruit is too soft, and too pale in color to commend it for market, even if it were sufficiently productive. Governor Hoard did not meet expectations. The Edgar Queen strawberry, of which plants were received in the spring of 1890, from Mr. B. O. Curtis, of Paris, Ill., was also tested, but through an error, the yield could not be given in the diagram. The plants were decidedly productive, and the fruit was about the size and quality of that of the Sharpless.

Notes on the quality of the other varieties were given in the report of this Station for 1890.

Illustrations, drawn from nature, and natural size, are presented of some of the varieties that are now attracting most attention. The specimens illustrated were taken in every case, after one or more pickings had been made, and hence the drawings are not of the largest fruits borne by the varieties. They are, however, from samples of good average size.

10—Ex. FIG. 5.—Warfield No. 2.

FIG. 6.—Haverland.

FIG. 7.—Eureka.

FIG. 8.--Gandy.

FIG. 9.—Van Deman.

FIG. 10.—Bubach No. 5.

Raspberry. The following varieties came into bearing at our Station for the first time the past season.

Thompson's Early Prolific. The first berries ripened July 3. They were of medium size, and of a beautiful bright scarlet color, even when fully ripe. In quality they were sweet and tender, but not rich. The plants were quite vigorous and prolific, and the canes were free from thorns.

Thompson's Early Pride. First berries ripe July 10; very similar in size, color and quality to those of the above, but the plants were less vigorous and prolific, and the canes were clothed with numerous short prickles.

Muskingum. A few berries were ripe July 17. The fruit was medium to large, firm, dull purplish red when fully ripe, with a decidedly tart flavor, but lacking in richness, The plants were extremely vigorous and productive, with strong canes on which were a few short but rigid thorns.

Gladstone. A few berries were ripe July 5. They were of medium size, of a dull dark red color, and of excellent quality, but only moderately firm. The plants resembled in general character those of the last, but were somewhat less vigorous and productive.

This variety yielded a second crop in autumn, of which the berries commenced ripening early in September, and continued to mature until hard frosts. The yield of the second crop, while probably not equal to that of the first, was good, and the quality was excellent.

A BREEDING EXPERIMENT WITH TOMATOES.

E. S. GOFF.

The extent to which plants may be modified by selection of seed, is of interest both to the practical cultivator, and the man of science. Few systematic experiments bearing upon this subject appear to have been reported. The one here given is not regarded as complete, but the results are thought of sufficient interest to merit presentation.

In the fall of 1883, seed was taken by the writer, then at the New York Agricultural Experiment Station at Geneva, from thoroughly mature fruits of the Cook's Favorite tomato, and at the same time from other fruits that showed no external indications of maturity. The latter fruits had nearly attained their full size, but had not commenced to change color toward ripeness. The following season (1884), plants were grown from both these selections of seed, and in the autumn, seeds were taken as before, i. e., from ripe fruits from the plants grown from ripe fruits, and from immature fruits from those grown from immature fruits. Plants were again grown from the two selections of seed in 1885, when seeds were again taken from the two strains as before, from which other plants were grown in 1886. From the latter crop, seeds were again saved, which were, however, not planted until the spring of 1889, when plants were grown from them at this Station, and the two strains have been continued up to the present time. We have therefore, one strain of the tomato grown through six generations from seeds known to be fully mature in every case, and another strain of the same variety, grown the same number of generations, from seeds taken from fruits that had not commenced to change color toward ripeness. The two

strains have been grown side by side throughout the experiment. What has been the effect upon the plants?

As a partial answer to this question, the reader is referred to the accompanying illustrations, which represent a plant of each strain; the first illustration being the strain from the mature seed, and the second the one from immature seed.

FIG. 11. Plant of Cook's Favorite tomato, grown six generations from fully matured seed.

FIG. 12. Plant of Cook's Favorite tomato, grown six generations from immature seed.

It appears clearly from the illustrations, that the use of immature seed has had the effect to very perceptably reduce the growth of the plant, and at the same time, to increase its prolificacy. But the illustration shows this truth but partially, as the following figures will testify. The foliage and stems of ten plants grown from the ripe seed the past season, from which the fruit had all been picked, weighed on September 21st, 149 pounds, while the same number

from the immature seed weighed but 65½ pounds. These ten plants from the ripe seed had matured up to September 19th, 1,298 fruits, weighing 57,127.2 grammes, while the ten plants from the unripe seed had matured at the same time, 2,519 fruits, weighing 102,376.6 grammes. The real difference in the growth and productiveness of the two strains will more readily appear from the accompanying diagrams.

FIG. 13.—The comparative growth of stems and foliage (by weight) of plants grown from mature and immature seeds.—a, the plants from mature seed; b, those from immature seed.

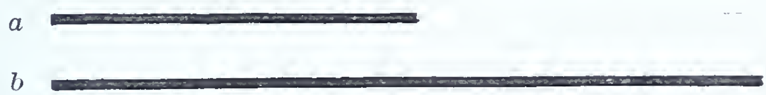


FIG. 14.—The comparative number of fruits that ripened up to September 19, on plants grown from mature and immature seed—a, plants from mature seed; b, those from immature seed.

The following diagram, Fig. 15, shows the comparative weight of these fruits:

FIG. 15.

But these differences are by no means the only ones apparent in the two strains. The use of immature seed has clearly tended to *promote early maturity*, though the degree to which this influence has been manifest has not been uniform in different seasons. The first season (1884), the plants from unripe seed matured their first fruit 20 days in advance of those from the ripe seed, and they had matured ten fruits ten days in advance of the latter.[1] In 1885 the two strains ripened their first fruits on the same day, though the one from unripe seed matured ten fruits seven days in advance of the other.[2] In 1886, and in 1889, the dates of first maturity were not noted. In 1890, the strain from immature seed ripened its first fruit eight days, and 1891 at

[1] Report N. Y. Agr. Expt. Station, 1884, 224.

[2] Ib. 1885, 209.

least fourteen days in advance of the other. Dr. J. C. Arthur, who grew the two strains at the Indiana Experiment Station, in 1890, secured a greater earliness of three weeks from the immature seed.[1] It thus appears that in the five trials in which the dates of first maturity were noted, the strain from unripe seed gave its first ripe fruit, on the average, 12.6 days earlier than the other strain.

The *size of the fruits* has been reduced slightly with the use of immature seed. Thus the fruits from the unripe seed averaged in weight 40.64 grammes, while those from the mature fruits averaged 44.01 grammes.

The *firmness* of the fruit from the immature seed has been somewhat less than that from the ripe seed, the rind being slightly thinner. A somewhat greater tendency to ripen unevenly has also been manifest, the fruit often being found slightly green at the center, when appearing quite ripe externally.

In *keeping quality*, the fruit from the immature seed has generally been inferior to that from the ripe seed, but the past season this difference scarcely appeared, both strains having kept remarkably well when picked from the plant. The fruit from the immature seed was, however, rather more subject to decay when left on the vines, and has always shown a greater tendency to crack after rain.

The *form of the fruit* has been very perceptibly affected, being rendered more oblate. Thus in forty typical fruits from the ripe seed measured the past season, the axial diameter was to the transverse diameter as 1 to 1.125, while in the same number from the unripe seed, it was as 1 to 1.313. Similar differences were noted in previous years.

The *number of cells* appears to have been affected. The forty typical fruits noted above from the ripe seed contained a total of 97 cells, while those from the unripe seed contained a total of 128 cells. A similar difference was noted by Dr. Arthur in 1890.[1]

The *tendency of the fruit to grow double* has increased with the use of immature seed. In the yield of ten plants

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[1] Private letter.

from the mature seed, only two and one-half per cent. of the fruits that ripened between August 17 and September 19 were double; while in that of the same number from the immature seed, eight per cent. were double. Similar differences have been noted in previous years.

The *proportion of seed* to the weight of the fruit appears to have been affected. Five typical fruits from mature seed contained 2.64 seeds to the gramme of fruit, while six typical fruits from the unripe seed contained 3.35 seeds per gramme.

The *weight of the seed* appears to have slightly increased with the use of immature seed. The seeds from the five typical fruits noted above, from the plants from ripe seed weighed 2.743 grammes per thousand, while those from the six fruits from unripe seed weighed 2.804 grammes per thousand. Another sample of seed from the mature seed strain weighed 2.323 grammes per thousand, and a second from the unripe seed strain weighed 2.757 grammes per thousand. It should be remembered that these seeds were all from mature fruits.

The *posture of the plant* seems to have been rendered more decumbent by the use of immature seed, a fact noticeable throughout the experiment.

The *aspect of the foliage* has been affected in a conspicuous manner. The shade of color has been uniformly lighter in the plants from unripe seed, and the tendency to blight has been noticably greater in this strain. The surface of the leaflets has also assumed a much more blistered appearance in the plants from immature seed, than in those from ripe seed.

The *germinative power* of the unripe seeds has been uniformly very low. In 1884, seeds from a very immature fruit vegetated but 2 per cent., while seeds from a ripe fruit in the same trial vegetated 96 per cent. The immature seeds planted in the spring of 1891, tested in the Geneva apparatus, showed a germination of 31 per cent., while the ripe seeds germinated 99.5 per cent. In three trials, the weight of the immature seed was found to be somewhat less than

that of mature seed. This was true whether the mature seed came from a plant grown from ripe, or unripe seed.

The *percentages of water and of ash* contained in the plants appear to have been affected, a decrease in the water content, and a corresponding increase of ash having been found in the plants from the unripe seed.

Another experiment that has been carried on as a companion to the one just described may be mentioned here. In the fall of 1883 a single plant in a row of the Little Gem tomato, a variety bearing a considerable resemblance to the Cook's Favorite, was observed to be much more feeble in growth and to have a larger percentage of decayed fruits than any other plant in the row. The fruits of this plant showed it to be the true Little Gem, and yet its habit and the appearance of its foliage indicated that it was not in a normal condition. In the hope of finding a clue to the cause of this feebleness, seeds were taken from some of the sound fruits from the feeble plant, and also from one of the other plants that was apparently in perfect health. The two samples of seeds were planted the following spring, and the two strains have been continued as in the preceding experiment, with the exception that after the first two seasons, the seeds of the feeble strain were taken from decayed, instead of from sound fruits. It is of interest that whatever the cause of the feebleness of the original plant as noted in 1883, the characters then observed have been faithfully maintained throughout the six generations. The feebleness appeared to increase during the first three plantings, but this has not been true of later plantings. What is more to the present purpose, the changes noted in the preceding experiment as accompanying the use of immature seed have been almost exactly duplicated in this instance. Whether or not the feebleness of the Little Gem plant, that served as the starting point of our second experiment, was due to the plant having been grown from immature seed, is not known. If it was, the second trial serves as a duplicate to the first. If it was not, the second experiment still has value, because it suggests that the changes that accompanied the use of immature seed may be due, primarily, to

a reduction of vigor, and would result from any cause that tends to reduce the vigor of the plant.

It may be added that there is no good evidence that the changes noted as accompanying the use of immature seed, or seed from the enfeebled plant tend to increase in degree as the plantings are continued. During the first three generations the feebleness of the feebler strains appeared to increase with each planting.[1] But this has not been true of later plantings. Indeed, during the past two seasons, the strain from unripe seed has appeared to slightly increase in vigor.

What practical lessons may be deduced from these experiments?

1st. The results suggest that in our climate, the tomato, at least its more rampant growing varieties, may be rendered more productive and earlier in maturing by a treatment that reduces the native vigor of the plant. Growing the plants on rather poor and dry soil, pinching the growing points, or root pruning should accomplish this end.

2nd. The health of plants is in a degree dependent upon the quality of the seed used. In these days of severe competition in the seed trade, dealers are doubtless often tempted to use immature or otherwise unsuitable stock for seed. The popular demand for cheap seeds tends to deteriorate quality in this commodity, and consequently in our crops, and to render the latter more subject to disease.

It must not be understood that the use of immature tomato seed is sanctioned or recommended in this article. The experiment is not as yet complete, and it is too early to announce its full teachings.

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[1] See Report of New York Agricultural Experiment Station, 1886, 169.

EXPERIMENT IN THE TREATMNT OF APPLE SCAB.

E. S. GOFF.

Experiments with the view of finding a more satisfactory preventive of apple scab, *Fusicladium dendriticum* Fckl. were carried on in the orchard of Mr. A. L. Hatch, of Ithaca, Wis., under the same arrangement as last season, viz. the work planned mainly by Mr. B. T. Galloway, of the U. S. Department of Agriculture, and executed by Mr. Hatch, under the direction of the writer.

The results were less decisive than were those of 1889, as detailed in our last report. The weather during the early summer proved excessively rainy, in consequence of which, it was sometimes necessary to postpone applications from day to day. The effects of some of the applications were undoubtedly destroyed by copious showers soon after the treatments.

The fungicides tested were:

1st. Copper carbonate dissolved in ammonia, as used in 1889, and also suspended in water.

2d. The so-called sulphur powder, used in 1889, and introduced by Mr. E. Bean, of Jacksonville, Fla.

3rd. A compound of copper sulphate and ammonium carbonate furnished by the Department of Agriculture under the provisional name "Mixture No. 5."

A detailed report of these experiments, with illustrations, was published in the Journal of Mycology, Vol. VII, pp. 17–25. A brief summary of results is, therefore, all that it seems necessary to present here.

The best results, and indeed the only ones that could be considered at all satisfactory, were secured where the spraying was commenced before bloom. In the crop of two trees, sprayed with the ammoniacal solution of car-

bonate of copper, once before bloom, and three times after, the percentage of fruits free from scab was 23.1, against 2.37 on trees not sprayed; while the percentage of fruits badly scabbed was but 25.5 against 64.78 on trees not sprayed.

Of the three fungicides used, the "Mixture No. 5" was rather more efficacious than the ammoniacal copper carbonate, but it injured the foliage considerably. Bean's sulphur powder had no visible effect either on the foliage or scab.

The following conclusions were suggested by the experiments:

1st. In seasons of excessive rains in early summer, the scab on badly infested trees cannot be wholly prevented by the methods tested.

2nd. Early treatment, and especially, at least one treatment previous to the opening of the flowers is extremely important.

3rd. Sprayings after midsummer are at best, of doubtful value.

4th. On trees badly infested with scab, the fruits that develop may be so far reduced in size by the fungus as to diminish the crop nearly 20 per cent., but this is doubtless but a small part of the injury actually produced.

WORK IN ECONOMIC ENTOMOLOGY.

E. S. GOFF.

A NEW METHOD OF APPLYING KEROSENE FOR INSECTS.

Kerosene is well known to be an effectual destroyer of insect life. When sufficiently diluted for safe use upon plants, it has proved a valuable insecticide for a class of insects not readily destroyed by other means. Emulsions of kerosene with soap and milk have been much used during recent years, and where the emulsion has been properly made, and used for insects to which it is adapted, the result has generally been satisfactory. The making of the emulsion, however, is accompanied with more or less difficulty, and not all who have attempted it have succeeded equally well.

Experiments were commenced by the writer during the summer of 1888, (see Report New York Agricultural Experiment Station, 1888), in the hope of discovering a method by which the kerosene and water could be so intimately commingled during the spraying process that the objects of the soap or milk emulsion could be fully attained without the necessity of preparing the emulsion separately. These experiments were continued during the seasons of 1890 and 1891, and the results are regarded as satisfactory.

The method is very simple, and consists in so constructing the lower valve seat of a pump that it allows the entrance of water through one opening, and kerosene through another; the two liquids becoming mixed in passing through the valves and cylinder of the pump, and finally broken up into an exceedingly fine spray by being forced through a good spraying nozzle.

The pump used in our experiments was the "Little Climax," made by the Nixon Nozzle and Machine Co., of Day-

ton, Ohio; but doubtless others of the spraying pumps now on the market would, with similar modification, answer quite as well. This pump, with its kerosene attachment, is shown in Fig. 16. The modification, is shown more in detail in figs. 17 and 18, Fig. 18 representing a vertical and Fig. 17 a transverse section of the valve seat.

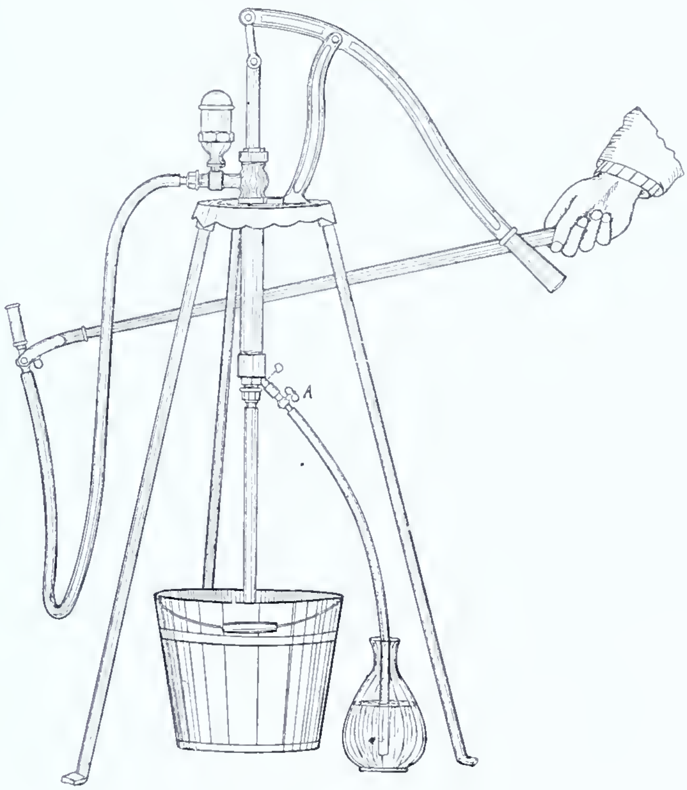

FIG. 16.

In the pump used the valves and valve seats are of brass. The lower valve, shown at A. Fig. 18, is held in place by a screw B. which fits into a bridge (C. Figs. 18 and 17) extend-

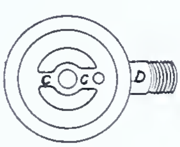

FIG. 17.

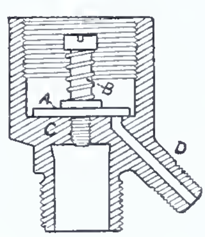

FIG. 18.

ing across the center of the orifice for the entrance of the water. In the modification of the pump a new casting was made, similar to the original one, except that it had a projection at one side (D. Fig. 16), so placed that a hole drilled through it lengthwise passes through the center of the bridge alluded to, near one end. To this projection is attached by a screw coupling a stop-cock (A. Fig. 16), and from this a lead or rubber tube extends into a vessel holding kerosene, the regular suction tube of the pump being inserted into a pail of water.

The operation of the pump scarcely needs explanation. The water enters through the ordinary channel, and at the same time, the kerosene enters through the smaller side channel, while the valve, in closing, closes both channels. If it is desired to change the proportion of kerosene, all that is necessary is to turn the stop-cock in the desired direction and when preferable to spray water only, the stop-cock may be closed, or both tubes may be placed in the water pail. A tested, graduated stop-cock may be used by which any given percentage of kerosene up to the capacity of the cock may be sprayed. The Nixon nozzle was chiefly used in our experiments, but the Vermorel nozzle appeared to work nearly or quite as well. No others have been used.

The mechanical mixture secured with this apparatus, while not absolutely permanent, has been found upon repeated experiments sufficiently slow of separation for safe use upon plants. When the spray is collected in a glass vessel, the liquid appears milky white. The kerosene rises at a rate proportionate to its amount, but the mixture retains its milky appearance for hours. Used upon foliage, no harm resulted, unless the proportion of kerosene was unduly large. The spray adheres to the foliage in a thin film from which the water very soon evaporates, leaving the kerosene to evaporate more slowly. The same process takes place when the soap or milk emulsion is used, except that these viscous substances probably somewhat retard the evaporation of both liquids.

The mechanical mixture of kerosene and water, as produced by the modified pump here described, was tested upon

the foliage of Arbor vitæ, Norway spruce, peony, rose, sweet william, oat, strawberry, apple, mountain ash, grape, raspberry, blackberry, plum, moon-flower, (*Ipomea*) and Chapman honey plant (*Echinops sphaerocephalus*). In no case did it prove injurious unless the amount of kerosene exceeded ten per cent., and in many cases it was quite harmless when used in much stronger proportion. The grade of kerosene used in every case was the common "headlight" illuminating oil.

Many other tests of the apparatus were made the past season, with the result that kerosene applied in this manner proved equally efficient as a destroyer of insects with the soap emulsion, and no more injurious to foliage. It is more penetrating than the soap emulsion, and is more satisfactory to use, as it passes through the pump much more readily.

Pumps intended for spraying kerosene in this manner should not have rubber packings, as the oil acts rapidly upon rubber. It did not appear to affect the hose, but the rubber piston of the pump used was soon destroyed. A leather piston, substituted for the rubber proved satisfactory and durable. The same applies to the kerosene emulsion.

It was also found that bisulphide of carbon sprayed with water through this attachment, makes a mixture that is sufficiently permanent for practical purposes.

The objection has been raised that since the method of using kerosene here described does not form a permanent emulsion, it must of necessity prove valueless. Obviously the true test of an insecticide is its efficiency in destroying insects without injuring the foliage of the plant upon which it is used. If it is here shown that kerosene may be safely used upon plants by a more simple and direct process than was heretofore known, a step of progress has been made.

The use of mechanical mixtures of kerosene and water against insects upon plants is by no means new. Experiments in this direction appear to have been commenced very soon after the oil came into use for illuminating pur-

poses. In the Gardener's Monthly for 1866, p. 176, is an article by Mr. Thomas Meehan, referring to the use of "Coal Oil" for the "Cabbage fly," as a treatment that had long been known, and recommending to add a tablespoonful of the oil to a water pot of water, stirring the liquids together while watering. At p. 208, of the same volume is given a detailed account of experiments made by Mr. Meehan with kerosene upon a number of species of plants.

An apparatus for securing a thorough and rapid mixture of kerosene and water during the spraying process, has not to my knowledge, before been devised.

The attachment is not patented.

NOTES ON CUT-WORMS.

Cut-worms were very numerous, on fall plowed clover sod, both in the spring of 1890 and '91. Certain observations and experiments were made, the results of which have some bearing upon treatment for this pest.

Trapping the worms beneath piles of poisoned clover was thoroughly tested both seasons. It was successful so far as securing the worms was concerned. Handfuls of fresh clover deposited on ground infested with cut-worms, serve as a hiding place for these insects at the close of their nightly foragings. It was not uncommon to find 10 and even 20 cut-worms beneath a single clover pile, and it was observed that the worms continued to congregate beneath the same piles for two or three days, or until the clover became dry. But clover appeared to be no better for this purpose than other green materials, as rye, grass, and prickly comfrey. The worms also congregate in large numbers beneath clover sods that chance to lie on the surface of a plowed field, even after these become dry.

But the application of poison to the clover or other green material used for entrapping the cut-worms proved far from effectual in destroying the latter. The first impression on looking beneath a pile of poisoned vegetation on the ground is that the cut-worms found under it are dead. They are motionless for the time being, and show no signs of life. As

a matter of fact, however, they are often only paralyzed by fright. If watched for a moment, some of the worms begin to move, and in time, most of them are usually found to be alive.

Several tests showed that the proportion of worms that may be poisoned in this manner is surprisingly small. In the first trial (May 14, 1891) thirteen worms taken from beneath piles of clover that had been dipped in water containing Paris green at the rate of half a tea-spoon full to three gallons, were placed in a fruit jar, and left there over night. The next morning seven of them were unquestionably alive. One hundred and ninety cut-worms from piles similarly treated were next placed in a close box upon an inverted flower-pot saucer raised eight inches above the bottom of the box. The next morning, only 22 cut-worms remained on the saucer, the remaining ones having crawled to the edge and fallen to the bottom of the box, and of these, six were afterward found to be alive. The proportion of Paris green used on the clover was then doubled, and on May 18th, 218 cut-worms taken from piles that had been treated with the stronger mixture were subjected to a similar test. Of these only 51 were found to be dead the next day. In another test 165 worms were taken from the poisoned piles, and the next day only 70 gave any indications of being dead. Of 37 others, only two were dead, and of 23 others but one was dead, and that one was injured. It thus appears that out of 646 cut-worms all of which had been some hours beneath the poisoned clover piles, not more than 146 or less than 23 per cent., could have been killed by the poison. It would seem of great importance to gather the cut-worms daily from beneath the piles if any marked benefit is to result.

Can we hope to exhaust the soil of cut-worms by regularly gathering all the worms that take refuge under the clover piles? Not apparently within a fortnight, though there are indications that their number may be considerably reduced in this time. In the test made, a frame fourteen feet square made of ten inch boards placed edgewise, was set in the ground to the depth of eight inches. On the

upper edge of the boards forming the frame narrower boards were nailed horizontally, so as to form a projecting ledge on both sides of the frame. Thus the worms could not readily crawl over the frame, and none could crawl under it without burrowing to the depth of at least 8 inches. Clover piles were then placed from day to day within the frame, and others just outside of the frame, and the worms hiding beneath the piles both outside and inside the frame were counted and destroyed from time to time, with the following results:

DATE.	Cut-worms found within the frame.	Cut-worms found outside the frame.
May 20	9 beneath 6 piles.	4 beneath 9 piles.
May 21	21 beneath 6 piles.	2 beneath 12 piles.
May 23	20 beneath 6 piles.	2 beneath 12 piles.
May 26	13 beneath 8 piles.	11 beneath 12 piles.
May 28	2 beneath 4 piles.	6 beneath 8 piles.
May 29	1 beneath 4 piles.	2 beneath 4 piles.
June 2	9 beneath 4 piles.	22 beneath 4 piles.
June 4	2 beneath 4 piles.	9 beneath 4 piles.
June 5	1 beneath 4 piles.	1 beneath 4 piles.

There were indications that cabbage plants attract the cut-worm by their odor. In a bed of cabbages, each alternate row of which had its plants surrounded with tarred paper cards as an experiment in preventing the attack of the cabbage maggot, the cut-worms congregated in considerable numbers beneath the cards surrounding the plants, while very few were found beneath similar cards placed between the rows. The ground to the west of the cabbage plat was found much more infested with worms than that to the east of it, and the worms beneath the cards of the west row of cabbages were much more numerous than in the central and eastern rows, indicating a migration of worms from the west side.

It is very plain, however, that cut-worms are not repelled by the odor of coal tar, otherwise they could hardly have rested so complacently during the day beneath cards saturated with this odoriferous material.

A NEW PREVENTIVE AGAINST THE CABBAGE MAGGOT.

Growers of early cabbages are too familiar with the larva of the cabbage root maggot *Anthomyia brassicae.* The female of the perfect form of this insect, which closely resembles the common house fly, lays its eggs upon the stem of early cabbage plants soon after transplanting, and the larva, on hatching, eats into the tender root, upon which it feeds, destroying the smaller branches and even the main root itself. Plants thus affected are either seriously retarded in growth, or die outright. Entire plantings of early cabbage are often almost ruined from this cause, and though many so-called remedies for the trouble have been published, the only practicable one heretofore known has been the primitive method of digging about each plant and removing the maggots one by one.

About the year 1887, Prof. W. W. Tracy of Detroit, Mich., conceived the idea of intercepting the entrance of the newly hatched larva into the root of the young cabbage plant by placing a bit of heavy paper in a horizontal position closely about the stem at the surface of the ground. It was found that the female insect, being unable to reach the stem at the surface of the soil, would deposit her eggs upon the paper, where they would soon become dry and fail to hatch. But certain difficulties were encountered in carrying out this idea. In order to place the paper about the plant, it was necessary to cut a slit to the center of the slip or card and then to cut a small roundish hole to accommodate the stem. The stems of the plants not being of a uniform size, did not always fit the holes for them. If the hole proved a little too large, the fly could still gain access to the stem at the surface of the soil, and deposits her eggs in spite of the card. If, on the other hand, the hole did not happen to be quite large enough, the slit of the card would not quite close, and so the fly would again find access. Moreover, the paper absorbed moisture from the soil on the lower side, causing this side to swell which warped the edges sufficiently to permit the wind to lift it, and even to blow it away in many cases. The method not being found satis-

factory by Prof. Tracy and others who tested it, was abandoned.

In the spring of 1889, it occurred to the writer to substitute tarred paper for the manilla paper previously used, with the additional protection of adding a bit of grafting wax to secure a union between the paper and the stem. This proved entirely successful. In a row of early cabbages thus treated, not a single plant was attacked by the maggot, while in rows not treated, every plant was infested. The tarred paper without the grafting wax was nearly a complete remedy, but where manilla paper was used without wax, almost every plant was infested.

The next season (1890), preparations were made for a more extensive trial of the tarred paper cards, and a tool was devised for cutting out at one operation a hexagonal card, with a slit reaching to the center, and with a star-shaped cut at the center, so that the same card may accommodate itself to any sized stem, and still make a tight joint. In order to secure a trial of the devise in other localities than at our own Station, small packages of these cards were sent to several gardeners in this and other states with the request that they be used and reported upon. A considerable planting of cabbages at our Station also received the cards on alternate rows, at the time of setting the plants. The season, however, proved quite unfavorable for the development of the maggot, being very rainy during June, and few who applied the cards were able to make any report. An exception occurred in the gardens of J. M. Smith, and of Smith Brothers, at Green Bay. These gentlemen were visited with their accustomed attack of maggots, and were able to give the cards a thorough trial. Their reports are appended:

Report of J. M. Smith, of Green Bay, 1890:

"I have for many years been very much annoyed by what we call the cabbage maggot, at the roots of our early cabbage plants. We have often lost nearly the entire setting for early cabbage, and have never found any remedy except to dig around the plants and pick out the maggots by hand. This was expensive and not always satisfactory. The tarred paper remedy you gave me last spring, has thus far been about a perfect protection. I had some 7,000 or 8,000 of them thus protected, and the crop is a splendid

one, and will be fit for market in a few days. By the side of them we had about the same number unprotected, and should have lost nearly or quite the whole of them, but for the old system of hand picking. A single experiment is not apt to be conclusive, but this one seems to be as nearly so, as a single experiment can well be.

Yours truly,

J. M SMITH."

Messrs. Smith Brothers also reported verbally in 1890 to the effect that where the cards were used, no injury from the maggot occurred, but in an adjoining plot, where the plants were unprotected, most of them were destroyed.

The past season preparations were again made for a trial of the cards at our Station, but it was necessary to set the plants on ground where cabbage had not been grown for at least several years, and as in the preceding year, they were not attacked by the maggot. The Messrs. Smith, at Green Bay, however, repeated their trial on a more extended scale than in 1890, and their results were again satisfactory, as the following letters testify:

Report of J. M. Smith of Green Bay, 1891:

"August 17, 1891.

Your letter just received. One of two things is certain with regard to the disappearance of the cabbage maggot. The flies that are the parents of them have either disappeared, or the tarred paper is so distasteful to them that they will not lay their eggs about them. It is doubtless the latter. I used last spring, I do not know how many, but from 10,000 to 15,000 of them, and do not believe that we lost 25 plants from the maggot. In ordinary seasons we should have lost without the paper, from three-fourths to nine tenths of the plants.

Yours truly,

J. M. SMITH."

Report of Smith Brothers of Green Bay, 1891:

"We used about 15,000 of the tarred felt cards this season, and had no maggots except where the cards were not properly put on. We considered the test that we made last year so practical that we did not leave any of our early cabbage without the felt pads. This year a few of the plants were eaten, and in every case where we examined, the pad was torn and not properly put on. In our opinion they are a success, and we will use them on all of our early cabbage another year."

The use of the cards appears to have no effect upon the growing or heading of the plants.

For the benefit of those who may wish to adopt this treatment for early cabbage plants, an illustration is appended of one of the cards, natural size, and also of the tool used for cutting them out, the drawing of the latter being about one-half natural size.

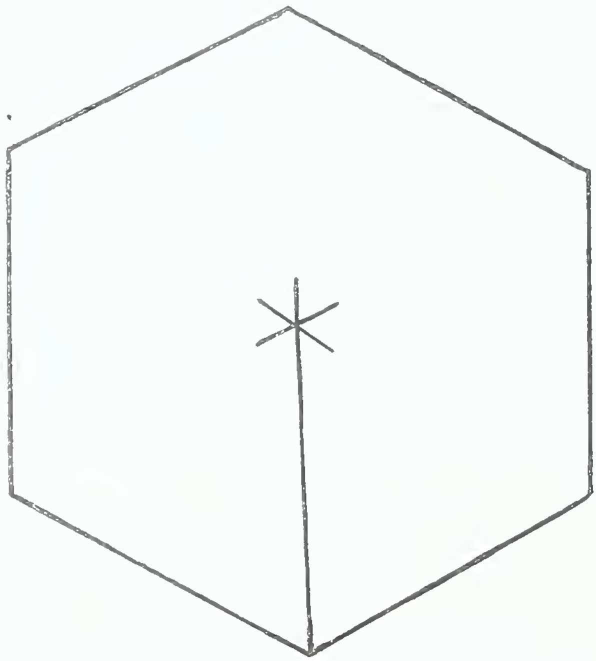

FIG. 19. Tarred paper card, for protecting cabbage plants from the root maggot.

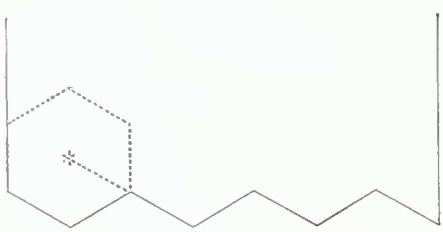

FIG. 20. Diagram showing how the tool is used. The dotted line indicates the position of the edge of the tool.

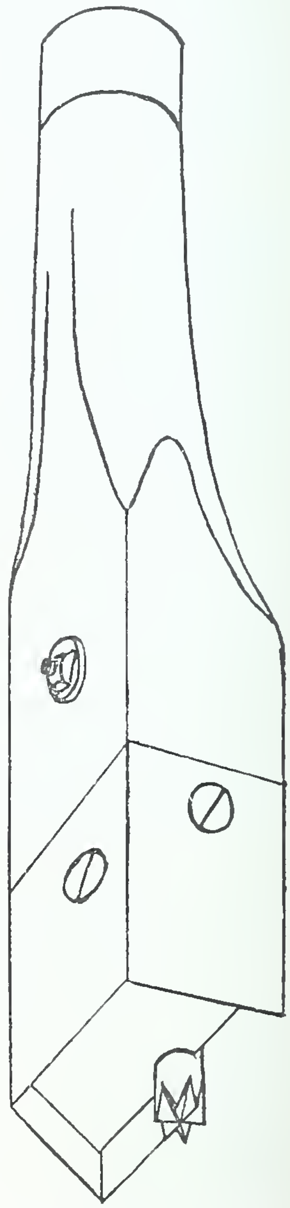

FIG. 21. Tool for cutting hexagonal cards.

The cards are cut in a hexagonal form, in order to better economize the material, and a thinner grade of tarred paper than the ordinary roofing felt is used, as it is not only cheaper, but being more flexible, the cards made from it are more readily placed about the plant without being torn.

The blade of the tool, which should be made by an expert blacksmith, is formed from a band of steel, bent in the form of a half hexagon, and then taking an acute angle, reaches nearly to the center, as shown in Fig. 21. The part making the star-shaped cut is formed from a separate piece of steel, so attached to the handle as to make a close joint with the blade. The latter is beveled from the outside all around, so that by removing the part making the star-shaped cut, the edge may be ground on a grindstone. It is important that the angles in the blade be made perfect, and that its outline represents an exact half hexagon.

To use the tool, place the tarred paper on the end of a section of a log or piece of timber and first cut the lower edge into notches, as indicated in Fig. 20, using only one angle of the tool. Then commence at the left side, and place the blade so that the acute angle just meets the bottom of the first notch, and the right side of this angle extends parallel with the sides of the paper. The first cut may make an imperfect card, but each succeeding cut makes an entire card until the other edge of the paper is reached.

The cards should be placed about the plants at the time of transplanting. By bending the card slightly, the slit will open sufficient to admit the stem of the plant to the center, after which the card should be spread out, and the points formed by the star-shaped cut should be pressed snugly about the stem.

EXPERIMENTS IN SPRAYING FOR THE APHIS.

The aphis was unusually destructive the past season, to the foliage of certain plants as the plum and snowball, (Viburnum) and in less degree to that of the apple, currant, and some other plants.

Experiments were made in the hope of finding a means of destroying the eggs of this insect by spraying during winter, while there are no leaves to interfere with the distribution of insecticides. The results, being almost wholly negative, need but a passing notice.

The material used was kerosene, diluted in different proportions. On March 25, 1891, two trees of the Tetofski apple were sprayed with the kerosene-soap emulsion, using ten per cent. of kerosene upon the first and twenty per cent. upon the second. The same day, two other trees were sprayed with kerosene and water, using the mechanical kerosene and water spraying attachment, elsewhere described in this report, and applying in one case 25 per cent. and in the other 30 per cent. of kerosene. The spraying was thoroughly done, and it was observed that the points where the eggs were lodged upon the branches, being usually in the angles between the buds and twigs, were the ones at which the sprayed liquids adhered longest to the trees.

On April 24, just as the buds were swelling, and the aphidæ were commencing to hatch, an examination showed that none of the sprayings had been effectual in destroying the eggs. Unfortunately, the orchard contained no other Tetofski trees to serve as checks, but it was clear that the trees were rapidly becoming infested with aphidæ, some buds at that time being nearly covered with them.

A second trial was made upon two large bushes of the common snowball, *Viburnum opulis*. On April 6, one of these was sprayed with a 20 per cent. kerosene emulsion, and the other with the mechanical mixture, containing the same amount of kerosene. On April 23 an examination revealed the fact that the aphidæ were hatching in great numbers upon both bushes, and no difference could be discerned in the number on these bushes and upon an adjacent one that had not been sprayed. It would seem that the only conclusion that could be reached from these trials is that the eggs of the aphis that affect the apple and *Viburnum opulis* are not destroyed by diluted kerosene unless the percentage of the latter shall exceed 20 per cent., and in the case of the apple, 30 per cent.

It may be well to add that no apparent injury followed these sprayings. In March of 1890, pure kerosene was used for spraying apple, and plum trees and currant and gooseberry bushes. The effect was not fatal in any case, but the currant and gooseberry bushes, and one of the apple trees were injured.

A spraying of kerosene-soap emulsion with 13 per cent. of kerosene made April 24, just as the buds of the apple were beginning to burst, was almost entirely successful in destroying the aphidæ. One of the same strength on a viburnum bush two days after the buds had commenced opening appeared to do very little good. The aphidæ had by this time, so effectually hidden themselves within the opening buds, that it was impossible to reach them with the spray. It is evident that the most vulnerable point with this insect is the time of swelling of the buds. On the apple and viburnum, at least, the eggs appear to hatch about the time that the bud's scales are bursting.

INVESTIGATIONS OF SUGAR BEET CULTURE IN WISCONSIN.

F. W. WOLL.

A. SUGAR BEETS GROWN AT THIS STATION, SEASON 1890.

Two plats, one of $1\frac{1}{3}$ acres, the other of $1\frac{1}{2}$ acres, designated in this report as plat A and plat B, respectively, were set apart for growing sugar beets during the season of 1890. The soil of both plats was a clay loam; heavy below but lighter above, with the surface soil showing a strong tendency to bake after rains; immediately after tillage when the ground is not wet, it is, however, a very satisfactory soil. Plat A was in clover the season of 1888; potatoes were grown on it in 1889. Plat B had been in clover the preceding year, and was fall-plowed in 1889. The effects of the preceding crops were most marked; although the potatoes were very carefully weeded, weeds nevertheless sprang up in great numbers this year and added materially to the cost of cultivation.

Four varieties were planted on plat A on May 27; the distance between the rows was 20 inches, and between beets in each row after last thinning, eight inches. On plat B three varieties were planted on May 28, the distance between the rows being 30 inches, with beets every ten inches in the row.

The beets received the very best treatment during their period of growth that the circumstances would allow; the heavy rains in the beginning and middle of June made cultivation impossible for a time, and gave the weeds more of a start than they would otherwise have had. The cultivation was done partly by a harrow tooth cultivator, by

a wheel hoe and shovel attachment with shields, or by hand. The weeds between the beets in each row could not be reached in any other way than by a hand hoe. The features of the growing season were with us, plenty of rain in May, June, August and October, with a temperature somewhat below normal during May, August and September, and higher than usual in June. The main meteorological data for the season are given in the following table:

Meteorological data for summer, 1890, *for Madison, Wis.**

	TEMPERATURE. ° F.				RAINFALL, INCHES.	
	Max.	Min.	Mean.	Mean normal.	1890.	Normal.
May	84	33	53.0	57.8	5.03	3.64
June	93	50	70 5	67.2	7.72	4.42
July	91	54	71.7	72.7	1.81	4.19
August	93	46	66.1	69.4	4.23	3.28
September	83	36	57.4	61.0	2.62	3.35
October	69	25	48.2	48.5	4.59	2.87
Total, May to October incl.					26 00	21.75

* From observations made at Washburn Observatory.

Samples of the beets grown on each plat were taken every week from September 5 and on; three or four beets of average size were pulled of each variety, and the average sugar content ascertained by the polariscope. While it is not believed that the beets sampled in every case represented the exact mean stage of growth of each variety at the time, the analysis may indicate, in a general way, the increase in suger content and in the purity of the juice of the beets during the fall; the following table gives the results of the weekly examinations of each plat. The average weightof the beets sampled is also given.

Plat A.

(Distance between rows 20 in., between beets in the row 8 in.)

	Dippe's Vilmorin.			*Bulteau Desprez Richest.*			*Dippes Klein-wanzleben.*			*Simon Le Grande White Improved.*				
	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Average per cent. sugar in juice.	Average purity co-efficient.
	Lbs			Lbs			Lbs			Lbs				
Sept. 5..... ...	0.99	11.87	78.2	0.53	10.79	73.4	.78	11.77	77.5	1.05	11.81	82.9	11.56	78.0
Sept. 15..... ...	1.22	12.91	86.6	1.27	12.72	80.2	1.06	13.02	83.4	1 30	12.51	77.7	12.79	82.0
Sept. 22..... ..	1.00	15.29	85.3	1.39	13.87	83.1	1.04	14.74	83.3	1.41	13.38	82.6	14 27	83.6
Sept. 30.	0.88	15.78	86.9	1.33	15.27	84.1	.90	14.06	82.7	1.09	15.38	84.7	15.12	84.[illegible]
Oct. 7..	1.18	17.64	85.6	1.27	14 85	83 9	1.30	16.14	83.7	.86	16.68	87.1	16.33	85.1
Oct. 16........	1.48	15.43*	84.5	1.24	15.52	86.1	1.07	14.33	84.8	1.98	14.60	84.2	14.97	84.9
Oct. 23....	.92	16.01	85.0	.71	16.63	87.2	1.20	15.92	87.7	1.12	16.15	83.8	16.03	85.9
Oct. 30..... ...	1.25	16.76	86.3	1.25	14.81	83.9	.90	16.39	82.2	1.51	15.74	83 2	15.93	83.9

* A sample taken Oct. 17 gave 16.37 per cent. of sugar, coefficient 84.9, average weight 1.17 pounds.

Plat B.

(Distance between rows 30 inches, between beets in the row 10 inches.)

	Dippe's Vilmorin.			*Le Maire's Richest*			*Florimo'd Desprez*				
	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. weight of beets.	Per cent. sucrose in juice.	Purity co-efficient.	Av. per cent. sugar.	Average Purity coefficient.
	Lbs.			Lbs.			Lbs.				
Sept. 9............	1.16	13.08	76 9	2.12	10.76	79.5	1.45	10.05	71.7	11.30	76 0
Sept. 15......... ...	1 08	12.17	80.1	1.40	9.88	74.3	1.75	10.14	72.5	10.73	75.6
Sept. 22............	.85	16 05	87.3	1.57	14.09	85.8	1.48	11.45	79.5	13.86	84.2
Sept. 30............	.89	17.32	84.9	1.27	14.37	83.8	2.44	13.44	82.9	15.04	83.9
Oct. 7............ ..	1.13	16 10	84.9	1 57	14.56	83.5	1.35	12.59	79.5	14.42	83 0
Oct. 16............	1.42	17.30	84.8	2.31	14.52	80 0	1.96	13.80	81.6	15.21	82.1
Oct. 24.	1.19	15.57	84.7	1.61	14.98	83.2	1.95	12.83	78.7	14.45	82.2
Nov. 1............	1 30	15.74	86 0	2.27	16.32	82 8	1.99	14.84	82 4	15.63	83.7

Perfectly representative samples were not always secured, as will be seen, but the analyses show nevertheless in a general way the change in the sugar content of the juice and its purity with the advance of the season. The last series of determinations for both plats were made at harvesting time; the results given for this date (Nov. 1) are the averages of three samples of beets, of four each, taken from different parts of the plat, the beets being average sized, and as nearly as could be, representative ones.

The results of the analyses are given in this report as per cent. of sucrose in the juice; to be able to refer the analyses to the beets themselves it is necessary to multiply the figures given by .95, as the beets will contain very nearly 95 per cent. of juice; thus, a beet containing 16.39 per cent. of sugar in the juice would contain 15.57 per cent. of sugar calculated on the weight of the beet; that is, 100 lbs. of beets would contain 15.57 lbs. of sugar, and one ton would contain 311.4 lbs. of sugar.

The *purity coefficient* of the beet juice means the proportion of the solid matter of the juice that is pure cane sugar; we find by the polariscope that the juice of a beet contains e. g. 15 per cent. of sugar; we also find that the juice is 1.075 times heavier than water (its specific gravity is 1.075); now we know that a solution of sugar in water of this specific gravity would contain 18.15 per cent. of pure sugar. We found only 15 per cent. in this juice; its purity coefficient consequently is $\frac{15}{18.15} = 82.7$ per cent. The purity coefficient of the juice from mature beets will vary from 80 to 90 or above, although as a rule it seldom goes above this limit when averages for a number of beets are considered.

It seems that the beets analyzed at our station reached full maturity during the first week of October; after that time the percentage of sugar and the purity of the same remained about stationary. The variations that we find in the above table between the different determinations are doubtless due to a large extent to one of the following facts: first, we find that, other conditions being equal, the larger beets contain a smaller percentage of sugar than do

smaller beets; and second, heavy rains diminish the percentage of sugar in the beets grown. From the 6th to the 15th of October last year we had heavy rains nearly every day, the total rainfall between these dates being for Madison 3.21 inches; the last portion of the month was also very rainy.

DATA OBTAINED AT HARVESTING TIME, OCT. 30.

The area taken up by each variety and the yield of beets as ascertained at harvesting time are given below:

Plat A.	Area grown.	Yield.	Per cent. sugar in the juice.
Dippe's Vilmorin	2,470 sq. ft.	3,040 lbs.	16.76
Bulteau Desprez Richest	8,352 sq. ft.	11,804 lbs.	14.81
Simon Le Grande White Improved	26,375 sq. ft.	27,866 lbs.	16.39
Dippe's Kleinwanzleben	28,750 sq. ft.	25,650 lbs.	15.74
Plat B			
Dippe's Vilmorin	13,311 sq. ft.	11,920 lbs.	15.74
Le Maire's Richest	22,264 sq. ft.	21,006 lbs.	16.32
Flor. Desprez Richest	20,685 sq. ft.	24,844 lbs.	14.84

Owing to the peculiar fall weather, in which the very wet ground froze during nights and thawed and became very sticky during day time, a considerable quantity of dirt adhered to the beets and made the digging a very laborious task. In order to ascertain the yield of washed beets per acre, a basketful of beets was taken from each load and weighed, each variety being kept by itself; when all loads from each variety had been brought from the field, the beets taken out were carefully washed, dried and weighed. In this way it was found that 10.5 to 24.8 per cent. of the weights recorded for the harvested beets was accounted for by adhering dirt; when corrections were made on the basis of these determinations, it was found that each variety had yielded the quantities of washed beets per acre given in the following table. The estimated yield of sugar per acre is also given in the table, the figures being based on the assumption that the beets contained 95 per cent. of juice:

Estimated yield of washed beets and of sugar per acre.

	Beets per acre.	Sugar per acre.
PLAT A. (BEETS 20 x 8 INCHES APART)		
Dippe's Vilmorin	40,420 lbs.	6,419 lbs.
Bulteau Desprez Richest	51,900 lbs.	7,304 lbs.
Simon Le Grande's White improved	39,930 lbs.	6,218 lbs.
Dippe's Kleinwanzleben	34,150 lbs.	5,106 lbs.
PLAT B. (BEETS 30 x 10 INCHES APART.)		
Dippe's Vilmorin	29,430 lbs.	4,399 lbs.
Le Maire's Richest	34,630 lbs.	5,368 lbs.
Florimond Desprez Richest	46.710 lbs.	6,575 lbs.

The varieties grown would rank in the following order when either their yield or their sugar-producing capacity is considered: 1. Bulteau Desprez Richest. 2. Florimond Desprez Richest. 3. Dippe's Vilmorin (Plat A). 4. Simon Le Grande's White Improved. 5. Le Maire's Richest. 6. Dippe's Kleinwanzleben. 7. Dippe's Vilmorin (Plat B). It will be seen that the beets yielded from fifteen to twenty-six tons per acre, with an estimated yield of sugar of two to over three and one-half tons per acre. The closer planting gave the richest beets and the larger yield of beets; the beets on Plat B were larger than those on Plat A, and contained a lower percentage of sugar (p. 178).

QUANTITY OF TOPS OBTAINED FROM BEETS.

The tops from a number of beets were weighed separately when the first determination was made, September 5, and also at harvesting time, to obtain some data as regards the proportionate increase of the beet root with its period of growth, and also the relation of tops to washed roots with the different varieties.

Proportion of washed beets to tops.

	For each 100 lbs. of beets the following numbers of lbs. of tops were obtained:	
	On Sept. 5.	On Nov. 1.
Plat A.:		
Vilmorin	60	34
Bulteau	132	17
Simon Le Grande	68	23
Kleinwanzleben	79	....
Plat B.:		
Vilmorin	84	37
Le Maire's Richest	79	36
Florimond	66	36

As has always been found, the proportion of leaves is largest in the earlier stages of growth of the plant; between the different varieties, there is some difference, Bulteau and Simon Le Grande's White Improved containing a smaller proportion of leaves at the time of harvesting than the other varieties. According to the data obtained the yield of fresh tops per acre would be from four to eight tons.

Summing up the discussion of our work for the last season, we notice that the yield of sugar beets obtained as well as their sugar content was very satisfactory. The season could not be considered especially favorable to sugar beet culture on account of the heavy rains in the fall; when in spite of this we secured crops of fifteen to twenty-five tons per acre of beets containing a good percentage of sugar, it would seem that the question, whether or not sugar beet culture may prove profitable with us, cannot be answered in any other way than the affirmative.

B. WORK DONE AT SUB-STATIONS.

Five sub-stations were established in different parts of our state to study the adaptability of the different sections to sugar beet culture. The names of the farmers who under-

took the work, with their post office addresses, are as follows:

F. W. Roberts, Woodworth, Kenosha county.

Paul M. Peirce, Germania, Marquette county.

Fred Burton, Janesville, Rock county.

L. F. Noyes, Hudson, St. Croix county.

A. L. Grengo, Colgate, Waukesha county.

Of these stations, three lie in the southern portion of our state, viz.: Woodworth, near Lake Michigan; Janesville at about the same latitude in the inner part of our state, and Colgate about twelve miles west of Milwaukee. Germania lies in the central portion of the state, about fifty miles north of Madison; Hudson lies in the northwestern corner of the state, about ten miles east of St. Paul (at 45° latitude).

Directions were sent to select a small piece of land, about three square rods, of a kind that would produce a good crop of potatoes; to give the beets good cultivation, and to keep careful notes as regards labor spent and method of planting and cultivation. The following varieties were sent to each sub-station: Bulteau Desprez Richest, Simon Le Grande's White Improved, and Dippe's Kleinwanzleben. The data as to the kind of soil, time of planting, &c., are given in the following table:

Data concerning sub stations.

	Woodwo'th Kenosha county.	Germania, Marquette county.	Janesville, Rock county.	Hudson, St. Croix county.	Colgate, Waukesha county.
Kind of soil	Light sandy.	Loam.	Black loam	Black sandy.	Clay loam.
Area planted of each variety, sq. ft	797	550	812	817	1,224
Previous crop on land	Potatoes.	Clover.	Pasture.	Oats.	Timothy.
Date of planting	May 20.	May 29.	May 15.	May 19.	May 31.
Distance between rows	18 in.	18 in.	20 in.	18 in.	18 in.
Distance between beets after last thinning	4–6 in.	6 in.	6 in.	*	8 in.
Hours spent in cultivating and thinning plat	24 hours.	45 hours.	37 hours.	20 hours.	54 hours.
Date of harvesting	Oct. 28.	Oct. 28.	Oct. 28.	Oct. 29.	Nov. 16.

* Simon Le Grande, 16 in.; Kleinwanzleben, 12 in.; Bulteau Desprez Richest, 20 in. Seed did not all grow, hence the great distance between beets in the row.

In order to study the development of the beets at each place during the fall, four samples of each variety grown were secured from each sub-station between the middle of September and the date of harvesting. On the arrival of the samples at this Station, they were weighed, and the juice expressed and polarized. The results of the examination are given in the following table:

Beets from sub-stations.

1. FROM F. W. ROBERTS, WOODWORTH, WIS.

DATE.	BULTEAU.			SIMON LE GRANDE.			KLEINWANZLEBEN.		
	Av. wt. of beets. Lbs.	Per cent. sucrose in juice	Purity co-efficient.	Av. wt. of beets. Lbs.	Per cent sucrose in juice	Purity co-efficient.	Av. wt. of beets. Lbs.	Per cent. sucrose in juice	Purity co-efficient.
Sept. 18	.52	10.72	77.7	1.00	10.69	80.3	1.02	12.37	85.3
Oct. 8	1.01	10.26	75.3	1.04	12.51	81.2	.99	12.91	81.5
Oct. 15	1.72	9.87	74.9	1.29	11.77	80.7	1.80	11.96	79.5
Oct. 30	1.35	12.81	79.6	1.28	12.87	78.9	1.29	13.45	79.6
2. FROM PAUL M. PEIRCE, GERMANIA, WIS.									
Sept. 23	.72	12.04	80.8	1.02	12.70	80.1	.84	13.93	91.7
Oct. 7	.55	12 98	83.1	1.20	13.41	82.8	1.22	13.84	85.4
Oct. 18	1.50	13.58	85.7	.94	13.05	82.2	1.76	13.27	81.9
Nov. 4	1.59	13.79	83.2	1.73	13 68	83.2	1.83	15.50	84.9
3. FROM FRED BURTON, JANESVILLE, WIS.									
Sept. 25	1.34	15.24	85.1	1.24	14.14	83.2	1.51	13.75	77.2
Oct 8	.96	16.00	80.2	.92	15.08	82.6	.93	14.40	81.9
Oct. 17	1.06	13.17	83.0	1.28	15.29	79 8	1.48	13.80	82.3
Nov. 7	1 22	14.77	85.2	1.14	13.04	82.8	1.06	14.31	83.1
4. FROM L. F. NOYES, HUDSON, WIS.									
Sept. 23	.43	13.14	78.2	.39	13.71	82.8	.46	13.91	85.3
Oct. 6	.50	14.84	78.8	.45	14.13	82.1	.36	14 86	83.0
Oct. 20	.41	14.89	79.6	.39	16.12	79.9	.35	16.83	84.4
Nov. 4	.46	12.99	75.5	.51	13.60	79.0	.54	15.44	83.5
5. FROM A. L. GRENGO, COLGATE, WIS.									
Sept. 26	1.11	14.92	86.0	1.08	14.69	85.4	1.33	15.10	83 4
Oct. 9	1.47	16.25	81.4	1.68	15.07	80.0	2.29	14.42	81.5
Oct. 18	1.39	12.53	80 7	2.04	12.77	80.0	2.30	12.51	79.5
Nov. 12	1.83	17.14	84.5	1.74	15.95	87.4	2.30	14.95	83.2

It would seem from this table that the beets did not improve materially at any place as far as sugar content and purity of the juice are concerned, after the beginning of October. At the Janesville sub-station the beets seem to have been as mature and rich on the 25th of September as at any time later on. At the Hudson station the beets never grew large (weighing on the average not more than half a pound a piece), and they seem to have been about as far advanced when the first samples were taken, as later on; the light yield is explained by the cold wet weather at that place when the seed was planted, causing the seed to rot; potatoes planted there at the same time also rotted. The mean temperature and rainfall at St. Paul during the past season and normally were as follows:

Meteorological data for St. Paul, Minn., May–Oct., 1890.

	May.	June.	July.	Aug.	Sept.	Oct.	Total precip. May to Oct.
Mean temperature, 1890..........	52.2	69 8	71.9	65.0	58.2	46.0	....
Mean normal temperature...	58.4	67.1	71.6	69 5	58.9	47.1	....
Rainfall, 1890, inches.........	3.66	5.29	1.87	2.20	2.73	2.79	18.54
Normal rainfall, inches	3.34	4.85	3 26	3.67	3.38	2.05	20.55

The other sub stations produced beets of average size, with a good to fair percentage of sugar. The yield of beets at the different places may be seen from the following table, and also the estimated yield per acre:

Sugar beets from sub-stations.

NAME.	BULTEAU DESPREZ RICHEST.			
	Area grown, sq. ft.	Yield of beets, lbs.	Per cent. sugar in juice.	Yield per acre, lbs.
(1) F. W. Roberts, Woodworth	796.75	1,095	11.81	59,880
(2) P. M. Peirce, Germania	550	410	13.79	32,470
(3) Fred Burton, Janesville.................... ...	816.75	600	14.77	32,000
(4) L. F. Noyes, Hudson............	816.75	163	12.99	8,694
(5) A. L. Grengo, Colgate...	1,224	2,093	17.14	77,470

Name.	Simon Le Grande's White Improved.			
	Area grown, sq. ft.	Yield of beets, lbs.	Per cent. sugar in juice.	Yield per acre, lbs.
(1) F. W. Roberts, Woodworth	796.75	915	12.87	50,010
(2) P. M. Peirce, Germania	550	200	13.68	15,840
(3) Fred Burton, Janesville	816.75	486	13.04	25,880
(4) L. F. Noyes, Hudson	816.75	174	13.60	9,279
(5) A. L. Grengo, Colgate	1,224	1,851	15.95	67,410

Name.	Dippe's Kleinwanzleben.			
	Area grown, sq ft.	Yield of beets, lbs.	Per cent. sugar in juice.	Yield per acre, lbs.
(1) F. W. Roberts, Woodworth	796.75	1,075	13.45	58,790
(2) P. M. Peirce, Germania	550	610	15.50	48,310
(3) Fred Burton, Janesville	816.75	575	14.31	30,670
(4) L. F. Noyes, Hudson	816.75	185	15.44	9,868
(5) A. L. Grengo, Colgate	1,224	2,146	14.95	76,370

In judging these results, it must be remembered, that the area grown was small, and hence the yield per acre must be taken only as an indication of what might be reached under very favorable conditions. The yield found at the Colgate sub-station is higher than that of any of the other stations, going even above thirty-eight tons, in case of Bulteau Desprez Richest, and following closely with the other varieties. The yield of beets as well as their richness may be pronounced satisfactory in all cases, except in case of the Hudson station, where the yield was very light, for reasons already stated. The climatic conditions of the four southern stations probably did not vary very much from those of Madison, which have been previously given.

As it was deemed of some interest, the weights of leaves were ascertained at harvesting time along with those of the beets. In the following table are given the percentage weights of tops, calculated on weight of beets:

Relation between tops and beets at sub stations.

Sub-station at	*For every 100 lbs. of beets the following number of lbs. of tops were obtained:*		
	Bulteau Desprez Richest.	Simon Le Grande's White Imp.	Dippe's Kleinwanzleben.
Germania, Marquette County	67	60	50
Woodworth, Kenosha County	55	52	63
Janesville, Rock County	54	70	67
Hudson, St. Croix County	40	34	41
Colgate, Waukesha County	55	59	58
Average for each variety	54	55	56

C. EXAMINATION OF BEETS FROM FARMERS IN DIFFERENT PARTS OF THE STATE.

It remains to give an account of the work done during the past season in analyzing sugar beets grown by farmers in different parts of the state, the seed having been mostly obtained, either directly or indirectly, from the United States Department of Agriculture; all of the seed reported in the table to have come from this Station was received by us from Secretary Rusk, to whom credit is due for the favor. Realizing the importance of the sugar beet problem and the widespread interest in its solution, this Station had notices published in all newspapers in the state, offering to analyze, free of charge, beets grown anywhere in the state. As a result, seventy farmers in twenty-eight counties in the state sent in samples of sugar beets for analysis. The results are given in the following table, along with such information about the beets as it was possible to obtain, variety, soil, time of planting and harvesting, etc.:

Sugar beets in Wisconsin. Season 1890, *arranged alphabetically according to counties.*

No	Name of grower.	Post Office.	County.	Variety.	Seed obtained from	Time of planting.	Time of harvesting.	Soil.	Av. weight of beets, lbs.	Per cent. solids in juice.	Per cent. sugar in juice.	Purity coefficient.	Remarks.
1	John B. Meyer	Modena	Buffalo	White Silesian	S. Wilson, Mechanicsville, Penn.	May 3	Oct. 20	Black prairie	2.50	14.48	10.29	71.2	
2	Henry N. Peterson	New Holstein	Calumet	Kleinwanzleben	U. S. Dept. Agr.	Middle May	Oct. 23	Black loam	.88	21.40	17.91	83.7	
3	Herm. Kroehnke	New Holstein	Calumet	Kleinwanzleben	U. S. Dept. Agr.	May 20	Nov. 5	Loam	1.21	18.60	16.20	87.1	
4	Claus Edens	New Holstein	Calumet	Kleinwanzleben	U. S. Dept. Agr.	May 20	Nov. 1	Dark loam	.92	21.05	18.40	87.4	8 in apart, rows 16 in apart.
5	Aug. A. Paulsen	New Holstein	Calumet	Kleinwanzleben	U. S. Dept. Agr.	June 15	Nov. 1	Clay	.58	22.15	18.79	84.9	Unmanured.
6	Dr. E. F. Russell	Poynette	Columbia	Florimond	Wis. Exp. Station	June 4	Oct. 3	Heavy clay	2.01	15.40	11.68	75.8	Unmanured.
7	Dr. E. F. Russell	Poynette	Columbia	Florimond	Wis. Exp. Station	June 5	Sept. 30	Prairie	.71	15.52	9.97	64.2	Unmanured.
8	Dr. E. F. Russell	Poynette	Columbia	Florimond	Wis. Exp. Station	June 7	Oct. 1	Sandy loam	1.47	16.20	13.00	80.1	Unmanured.
9	Dr. E. F. Russell	Poynette	Columbia	Florimond	Wis. Exp. Station	June 5	Sept. 30	Prairie	1.88	15.85	10.95	69.1	Unmanured.
10	W. R. Chipman	Leeds Center	Columbia	Florimond	Wis. Exp. Station	May 31	Oct. 27	Black loam	4.14	15.85	12.59	81.4	Barny'd manure.
11	W. R. Chipman	Leeds Center	Columbia	Florimond	Wis. Exp. Station	May 31	Oct. 27	Black loam	1.91	16.20	12.86	79.5	Unmanured.
12	D. L. Cuff	Rocky Run	Columbia	Florimond	Wis. Exp. Station	June 10	Oct. 15	Sandy loam	3.81	15.52	11.59	74.9	
13	H. P. Johnson	Columbus	Columbia	Vilmorin	Wis. Exp. Station	June 1	Nov. 1	Clay	2.29	17.80	14.74	82.8	Unmanured.
14	Wm. Strhemil	Columbus	Columbia	Vilmorin	Wis. Exp. Station	June 1	Nov. 1	Black loam	5.56	15.05	10.93	82.7	Unmanured.
15	R. K. Beecham	Sun Prairie	Dane	Unknown	Jas. Vick, Rochester	June 1	Oct. 10	Heavy clay	3.12	11.65	8.26	70.9	Unmanured.
16	R. K. Beecham	Sun Prairie	Dane	Unknown	Jas. Vick, Rochester	June 1	Oct. 10	Heavy clay	2.70	11.05	8.18	74.0	Unmanured.
17	Leslie Wright	Danville	Dodge	Vilmorin	Wis. Exp. Station	May 28	Oct. 13	Yellow sandy loam	3.58	12.48	8.84	70.8	
18	P. C. Cooper	Danville	Dodge	Vilmorin	Wis. Exp. Station	May 29	Oct. 13	Yellow clay loam	3.55	15.28	12.13	79.5	Unmanured.
19	John Weston	Burnett	Dodge	Florimond	Wis. Exp. Station	May 30	Oct. 29	Black loam	.65	15.05	11.07	73.6	Barny'd manure.
20	Aug Woinowsky	Menomonie	Dunn	White Imperial	John Salzer, La Crosse, Wis.	May 30	Oct. 10	Sandy loam	1.91	12.94	9.45	73.0	Unmanured.
21	Aug. Peter	Menomonie	Dunn	White Imperial	John Salzer, La Crosse, Wis.	May 17	Oct. 11	Sandy loam	1.42	15.86	12.56	79.2	Unmanured.
22	Sam Welke	Fall Creek	Eau Claire	White Imperial	John Salzer, La Crosse, Wis.	May 5	Oct. 20	Fine sandy loam mixed with clay	2.21	12.48	7.91	63.4	Barny'd manure.
23	H. D. Hitt	Oakfield	Fo'd du L'c	Florimond	Wis. Exp. Station	May 29	Oct. 2	Heavy clay loam	1.87	17.19	12.81	74.7	Barny'd manure.
24	Wm. Merrel	Oak Center	Fo'd du L'c	Globe Sugar	Bryce & Ferguson, Waupaca.	May 30	Oct. 28	Clay loam	2.83	11.42	7.89	69.1	Raised for stock.
25	John H. Wise	Platteville	Grant	Florimond	Wis. Exp. Station	May 31	Oct. 20	Black loam	1.58	14.48	10.16	70.8	Barny'd manure.

26	John H. Wise....	Platteville..	Grant.....	Florimond.....	Wis. Exp. Station...	June 9	Oct. 20	Newly broken timber soil.	2.13	10.92	6.48	59.3	Unmanured.
27	John H. Wise....	Platteville...	Grant....	Florimond.. ...	Wis. Exp. Station...	June 2	Oct. 20	Black loam	3.16	11.42	6.82	59.7	Unmannred
28	Geo. M. Thomas.	Mineral Pt...	Iowa... ...	Flo.imond......	Wis. Exp. Station...	June 12	Oct. 16	Black soil......	1.37	16.78	13.19	78.6	Unmanured.
29	Geo. M. Thomas.	Mineral Pt...	Iowa.......	Florimond.. ..	Wis. Exp. Station...	June 12	Oct. 16	Black soil........	1.43	15.62	12.30	80.6	Unmanured.
30	Geo. E. Kelly....	Mineral Pt...	Iowa... ..	Florimond.. ..	Wis. Exp. Station...	May 21	Nov. 1	Clay.	1.30	15.62	11.98	76.7	Unmanured.
31	Geo. E. Kelly....	Mineral Pt...	Iowa......	Florimond.....	Wis. Exp. Station...	May 21	Nov. 1	Garden soil..	1.85	15.40	11.52	74.8	Barny'd manure.
32	R. Crossfield ..	Ft. Atkinson	Jefferson..	Vilmorin........	Wis. Exp. Station...	May 29	Oct. 1	Clay loam.......	1.10	16.90	12.91	76.6	Unmanured
33	Niles Deforest...	Ft. Atkinson.	Jefferson..	Vilmorin.	Wis. Exp. Station.	June 1	Oct. 1	Clay loam.	1.04	16.41	12.94	78.8	Unmanured.
34	John B. Millard..	Lake Mills...	Jefferson.	Vilmorin........	Wis. Exp. Station..	June 1	Oct. 20	Heavy dark loam	1.85	18.60	13.94	74.9	Unmanured.
35	John B. Millard..	Lake Mills...	Jefferson..	Vilmorin.....	Wis. Exp. Station...	June 1	Oct. 20	Red clay.	2.83	16.90	13.48	79.7	Unmanured.
36	Geo. W. Kindlin	Ft. Atkinson.	Jefferson..	Florimond.. ...	Wis. Exp. Station..	May 30	Oct. 6	Sandy loam ...	1.16	16.32	12.78	78.3	Barny'd manure.
37	F. A. Hoffman..	Jefferson....	Jefferson..	Vilmorin.......	Vaughan, Chicago..	April 29	Oct. 2	Rich clay loam..	2.39	15.51	11.55	74.5	Barny'd manure.
38	F. A. Hoffman..	Jefferson....	Jefferson..	Vilmorin.......	Vaughan, Chicago	April 29	Oct. 2	Rich clay loam..	3.27	14.59	10.98	75.8	Barny'd manure.
39	Peter Benz	Kewaunee...	Kewaunee.	Vilmorin........	....	....	Sept. 24	Heavy clay.. ..	2.66	17.70	13.96	78.9	
40	Frank Paula.....	Kewaunee...	Kewaunee.	Bohemian	Imported	....	Sept. 21	Heavy clay.. ..	1.69	10.91	7.63	69.3	
41	Joseph Jetek ...	Kewaunee...	Kewaunee.	Bohemian	Imported.	....	Sept. 21	Black clay soil ..	1.81	15.51	12.53	80.8	
42	Peter Benz......	Kewaunee...	Kewaunee.	Vilmorin	....	....	...	....	1.76	19.95	16.38	82.1	
43	Joseph Jetek ..	Kewaunee...	Kewaunee.	Bohemian.....	....	....	....	....	2.02	18.38	14.80	80.5	
44	Mates Plonhar..	Kewaunee...	Kewaunee.	Kleinwanzleben	Imported.	....	....	....	1.09	18.82	16.29	86.6	
45	Frank Albrecht.	Kewaunee...	Kewaunee.	Kleinwanzleben	....	....	....	....	1.53	17.70	14.72	83.2	
46	A Galenberger..	Kewaunee...	Kewaunee.	Kleinwanzleben	Imported	....	....	....	1.64	16.90	13.26	78.5	
47	W. Holnb..	Kewaunee..	Kewaunee.	K. P	Imported....... ..	....	....	....	1.15	18.70	16.78	89.7	
48	A. Matlick... ...	Kewaunee...	Kewaunee.	Bohemian.. ..	Imported...........	....	....	....	2.42	15.05	12.55	83.4	
49	F. Koinek... ...	Kewaunee...	Kewaunee.	Desprez	....	....	....	....	1.92	16.55	13.76	83.2	
50	Rev. Bergholz ..	Kewaunee...	Kewaunee.	Unknown...	....	....	....	....	3.26	14.25	9.98	69.4	
51	J. Jellineck, Jr..	Kewaunee...	Kewaunee.	Kleinwanzleben	U. S. Dep. Agr.......	May 10	Oct. 15	Clay.	2.12	21.40	17.25	80.6	Barny'd manure.
52	Math. Wochos...	Stangleville.	Kewaunee.	Desprez Richest	U. S. Dep. Agr... ..	May 20	Oct. 10	Sandy loam ...	1.89	20.18	17.31	55.8	Baruy'd manure.
53	John Dawson...	La Crosse ...	La Crosse..	Unknown.......	Jos Harris, Rochester, N. Y......	May 7	Nov. 5	Clay loam.......	3.38	13.18	9.85	74.7	Barny'd manure.
54	Thos. Mohr.. ...	Manitowoc..	Manitowoc	Unknown.......	A Landreth, Manitowoc..	May 15	Oct. 10	Black loam.....	1.46	18.70	15.24	81.5	Barny'd manure.
55	Thos Mohr.	Manitowoc..	Manitowoc	Unknown......	A. Landreth, Manitowoc..	May 15	Oct 10	Black loam ...	2.06	16.65	13.46	80.8	Barny'd manure.
56	A. Lindner......	Kiel..	Manitowoc	.. ..	.. ..	..	...	....	3.32	15.86	11.22	72.4	
57	Fred Burow....	W. Granville.	Milwaukee.	Imperial.......	Erfurt. Germany...	June 10	Oct. 25	Clay.	2.01	18.60	16.09	86.5	Barny'd manure.
58	Fred Burow....	W. Granville.	Milwaukee.	Mangold	Erfurt. Germany....	June 10	Oct. 25	Clay.	2.10	18.60	16.33	87.8	Barny'd manure.
59	G. H. Rawson...	Oak Creek..	Milwaukee.	Le Maire's.....	Wis. Exp. Station...	June 1	Nov. 3	Black sandy lo'm	2.02	18.02	15.33	85.1	Unmanured.
60	Julius Roebel....	W. Granville.	Milwaukee.	Le Maire's.. ..	U. S. Dept. Agr.....	May 20	Oct. 28	Black loam	1.82	19.28	17.08	88.6	Unmanured.
61	Julius Roebel....	W. Granville	... ..	Florimond . ..	U. S. Dept Agr.....	May 20	Oct. 28	Black loam	1.86	18.95	16.10	84.9	
62	S. Wehrman. ...	Binghampt'n	Ontagamie	. ...	J. Vick, Rochester..	May 15	Oct. 15	Black clayey ..	3.27	17.12	12.90	75.4	
63	E. Barkhausen..	Thiensville ..	Ozaukee...	Le Maire's.....	Wis. Exp. Station...	May 1	Oct. 19	Black sandy lo'm	.80	14.00	10.98	78.5	Unmanured.
64	H. Wehmhoff....	Burlington ..	Racine ...	Vilmorin	Wis. Exp. Station...	May 31	Oct. 9	Black sandy lo'm	1.91	17.22	13.86	80.5	Sheep manure.
65	F. E. Carswell...	Lone Rock ..	Richland ..	....	....	..	...	....	5.81	10.99	6.48	59.2	
66	E G. Snyder .	Clinton.. ...	Rock......	Vilmorin	Wis. Exp. Station...	June 7	Oct. 3	Sandy loam ...	.85	18.60	15.17	81.5	Unmanured.
67	P. F. Newell. ..	Jewett Mills.	St. Croix...	Vilmorin	Wis. Exp. Station...	June 1	Oct. 18	Black loam......	.96	18.70	14.37	76.9	Barny'd manure.
68	M. E. Seymour..	Reedsburg...	Sauk	Lane's Imperial	U. S. Dept. Agr....	May 15	Oct. 16	Black loam......	2.99	10.10	6.39	63.3	Unmanured.
69	J. W. Wood.....	Baraboo. ...	Sauk	Florimond	Wis. Exp. Station...	May 24	Oct. 3	Clay loam......	1.79	14.70	10.92	71.3	Barny'd manure.

Sugar beets in Wisconsin. Season 1890, arranged alphabetically according to counties.

No	Name of grower.	Post Office.	County.	Variety.	Seed obtained from	Time of planting.	Time of harvesting.	Soil.	Av. weight of beets, lbs.	Per cent. solids in juice	Per cent. sugar in juice.	Purity co-efficient.	Remarks.
70	A. E. Marker....	Reedsburg..	Sauk	French White Sugar.	D. M. Ferry & Co., Detroit, Mich.....	May 15	Oct. 15	Sandy loam.....	4.11	12.95	8.88	68.5	Barny'd manure.
71	E. A. Dwinnell..	N. Freedom..	Sauk	Lane's Imperial	U. S. Dept. Agr.....	May 15	Oct. 6	Clayey loam.....	2.64	13.55	10.37	76.5	
72	S. A. McCoy.	N. Freedom.	Sauk	Imperial Sugar.	U. S. Dept. Agr....	May 18	Oct. 8	Clay loam.......	2.93	12.72	8.69	68.3	Barny'd manure.
73	L. Ballschmieder	Sheb. Falls..	Sheboygan	Simon Le Gr'de	U. S. Dept. Agr...	May 18	Oct. 15	Black loam......	2.07	11.41	8.11	71.0	Unmanured.
74	L. Ballschmieder	Sheb. Falls..	Sheboygan	Lane's Imperial	D. M. Ferry & Co., Detroit, Mich......	May 12	Oct. 12	Sandy loam....	1.68	11.52	8.58	74.7	Unmanured.
75	L. Ballschmieder	Sheb. Falls..	Sheboygan	Kleinwanzleben	U. S. Dept. Agr...	May 18	Oct. 12	Black loam.....	1.19	14.70	11.55	78.6	Unmanured.
76	L. Ballschmieder	Sheb. Falls..	Sheboygan	Vilmorin	D. M. Ferry & Co., Detroit, Mich......	May 18	Oct. 16	Black loam	1.84	14.92	12.27	82.2	Unmanured.
77	L. Ballschmieder	Sheb. Falls..	Shedoygan	French Yellow.	Germany....	May 20	Oct. 15	Black loam......	1.80	11.52	8.08	70.1	Unmanured.
78	A. J. Lamberson	Whitehall....	Trempeal'u	Le Maire's....	Wis. Exp. Station...	June 10	Oct. 5	Black loam....	3.27	16.20	12.39	76.5	Unmanured.
79	Leslie Clark.	Galesville ...	Trempeal'u	Vilmorin	Wis. Exp. Station...	June 8	Oct. 12	Black heavy soil	1.70	16.20	12.86	79.4	Horse manure.
80	C. D. Wolfrum ..	West Bend ..	Washingt'n	Florimond......	Wis. Exp. Station...	May 30	Oct. 7	Hard clay ..	1.81	18.6	15.77	84.7	Unmanured.
81	F. Van Ruienen..	S. Germant'n	Washing'n.	Florimond	Creta, Neb	April 28	Sept. 10	Sandy loam....	3.06	17.80	14.74	82.8	Barny'd manure.
82	Mary Henrick...	S. Germant'n	Washing'n.	Florimond.. ...	Creta, Neb.	May 15	Oct. 16	Sandy loam...	1.39	17.70	14.58	32.4	Barny'd manure.
83	John Gebhardt.	S. Germant'n	Washing'n.	Florimond......	Creta Neb.	May 15	Oct. 15	Sandy loam....	2.29	16.42	13.45	81.9	Barny'd manure
84	John Gebhardt..	S. Germant'n	Washing'n	Unknown... ...	Men. Falls..	May 15	Oct. 15	Sandy loam...	2.24	14.35	11.27	78.5	Barny'd manere.
85	E. L. Nebs......	Men. Falls...	Waukesea..	Mangold.... ...	Germany	May 25	Oct. 17	Black loam....	2.29	17.55	14.35	81.7	Unmanured.
86	Mat. Debus.. ...	Men. Falls. .	Waukesha.	Mangold.... ...	Germany	May 25	Oct. 21	Black loam.....	3.95	17.35	14.12	84.4	Unmanured.
87	Mat. Debus......	Men. Falls...	Waukesha.	Vilmorin.......	Germany..	May 25	Oct. 21	Black loam....	2.06	17.35	13.88	79.9	Barny'd manure.
88	Mat. Debus..	Men. Falls..	Waukesha.	Imperial.......	Germany... ...	May 25	Oct. 21	Black loam ...	2.92	16.20	13.03	84.4	Barny'd manure.
89	John Bender	Oconomowoc	Waukesha.	Le Maire's....	Wis. Exp. Sta......	June 5	Oct. 8	Clay loam	2.67	14.82	11.16	75.3	Barny'd manure.
90	Chelsea E. Jones	N. Prairie....	Waukesha.	Vilmorin	Wis. Exp. Sta	May 29	Oct. 11	Sandy.	2.25	15.75	12.44	78.9	Barny'd manure.
91	Chas. Churchill .	Waupaca ...	Waupaca..	Le Maire's, ...	Wis. Exp. Sta......	June 1	Oct. 13	Loam.... ...	2.27	15.75	12.51	79.6	Unmanured.
92	B. L. Taylor....	Iola.........	Waupaca..	Le Maire's.. ..	Wis. Exp. Sta...	May 10	Oct. 15	Clayey loam. ...	2.92	17.35	18.82	79.7	Barny'd manure.
93	R. H. Fisher.....	Oshkosh.....	Winnebago	Imperial sugar.	Jno. A. Saizer, La Crosse............	May 12	Oct. 31	Black loam......	1.93	16.20	12.30	76.0	Barny'd manure.

The preceding analyses of sugar beets grown in this state during the season of 1890 have a very wide range, viz. from 6.39 to 18.79 per cent. of sugar in the juice; of the 93 analyses given in the above table, 19 come below 10 per cent. of sugar, 56 come above 12 per cent., 38 above 13 per cent. and 15 above 15 per cent. of sugar in the juice. But very few of the farmers who sent in beets for analysis had previously had any experience in growing beets; besides this some of the beets were grown for stock food, with no intention of testing their sugar producing capacity. Bearing this in mind, it would seem that the showing is a very creditable one; where grown for sugar and where good care was bestowed, the beets contained a higher percentage of sugar. As regards the yield, but very few and uncertain data were obtained, most of the farmers having grown only small plats from which an estimated yield was reported.

Any remarks as to what portions of the state would be best adapted to sugar beet culture will be deferred until we have more data to judge from. Of the localities from which several samples of beets were received during the past season, the country around New Holstein, Calumet county, and around Kewaunee, Kewaunee county, produced on an average the richest beets. A continued study of this subject may disclose other sections where sugar beet culture may be conducted successfully. The work has just been entered upon; from what has been done at this experiment station and at sub-stations in different parts of the state, we know that we can grow good crops of beets of a good quality; while the results reached so far would indicate that Wisconsin may prove well adapted to the culture of sugar beets, the work must be repeated for several seasons before we can consider the question fully settled.

SUMMARY.

Experiments in the culture of sugar beets were conducted in our state during the season of 1890 at this experiment station, at five sub-stations, one in each of the following counties, viz.: Walworth, Rock, Waukesha, Marquette,

St. Croix, and by seventy farmers in different parts of the state.

1. The six varieties of sugar beets grown at this Station contained from 14.81 to 16.76 per cent. of sugar in the juice; the coefficient of purity ranged from 82.2 to 86.3 per cent. About half an acre of each variety was grown and the yield of washed beets varied with the different varieties from 16 to 26 tons per acre. The estimated yield of sugar varied from 2 to 3½ tons per acre.

2. The beet culture at five sub-stations gave beets whose sugar contents ranged from 12.81 to 17.14 per cent. of sugar in the juice. with yields ranging from 4 tons to 39 tons per acre. The latter heavy yield was estimated from the plats grown at the Waukesha county station.

3. Seventy farmers in 29 counties of the state sent samples of sugar beets grown by them to this Station for analysis. The results of the analysis showed a very wide range, according to the kind of seed used, the manner of growing, skill of the grower, etc.; the lowest of all analysis showed 6.39 per cent. and the highest 18.79 per cent of sugar in the juice.

4. The result of our sugar beet investigations for the past year is very satisfactory and encourages the belief that Wisconsin is well adapted to sugar beet culture. Our people are urged to continue their interest in the matter, to move forward with caution, and in no case to enter upon the construction of beet sugar factories until there is positive assurance that the farmers will grow sufficient beets to keep the factory running for the whole working season, and that the soil of the particular locality is adapted to the crop.

COMPOSITION OF FEEDING STUFFS.

F. W. WOLL.

When the chemist speaks of the feeding stuffs used for the nutrition of farm animals, he employs certain technical terms, which, to the reader familiar with them, at once convey a full understanding of the fodder as far as its chemical composition is concerned; to those unfamiliar with these terms, on the other hand, they are wholly unintelligible. In the following, some brief explanations on this point will be given, in order to enable the reader to understand the discussions entered up at other places in this report and elsewhere, concerning the chemical composition of feeding stuffs.

The fodders are made up of I, *Water*, and II, *Dry Matter*.

I. *Water* is found in all feeding stuffs. It is present in by far the larger proportion in green and succulent fodders; out of 100 lbs. of pasture grass, 80 lbs. are water; green clover and silage contain about the same quantity of water, while mangolds and turnips contain as much as 90 lbs. out of every hundred pounds of fodder. In the different kinds of hay, straw and grain, the quantity of water present is only from 10 to 15 per cent. Water is determined by beating the fodder prepared for analysis for several hours at 212° F.

II. *Dry Matter* is what is left behind when all water is driven off the fodder. It is composed of (1) *Mineral matter* or *ash*, this being the non-combustible part of the plant, and (2) *Organic matter*. The *ash* goes to make the bone of the animal and to supply material for maintenance of other parts of the animal body. *The organic matter*, being the part of the fodder which is destroyed by combustion, is composed of the following groups of nutritive components,

(a) *fat*, (b) *crude protein*, (c) *crude fiber*, and (d) *nitrogen-free extract.*

a. *Fat or Ether extract,* includes what is dissolved out with dry ether from the water-free substance. Fat forms the main part of the extract; the other matters extracted are chlorophyll (the green coloring matter in plants), waxy substances, and various other bodies; the term *ether extract* has been used in the following, as it gives a truer name for the group than does *fat.*

b. *Crude protein* signifies a large number of bodies characterized by the fact that they all contain the element nitrogen, which none of the other components of organic matter contain. Crude protein includes *albuminoids* and *amides.* The *albuminoids* are the substances which go to make up the flesh, ligaments, tendons, etc., of the animal body; hence they are often called *flesh-formers.* White of egg, lean meat, curd of milk and gluten are typical albuminoids. The albuminoids are either insoluble in water or, if soluble, coagulate, that is, are rendered insoluble, by heat. In this they differ from the other group of nitrogenous organic bodies, the *amides.* These are all soluble in water. Asparagin and glutamin are the amides present in plants in the largest quantities. The nutritive value of amides is probably somewhat lower than that of the albuminoids, as they cannot fill all their functions. Their value has not yet, however, been fully ascertained, the study of this subject having only been taken up in later years. Amides are present in considerable quantities in immature plants, root crops and silage. They are only in a transitory state in the living plant, being later converted into albuminoids and serving as agents for the transfer of protein from one part of the plant to another.

The albuminoids contain on an average about 16 per cent. of nitrogen. In the chemical analyses, total nitrogen and albuminoid nitrogen are determined, the total nitrogen multiplied by 6.25 ($=\frac{100}{16}$) equals crude protein, and albuminoid nitrogen multiplied by 6.25 equals albuminoids; the difference gives the amides.

The protein bodies are considered of the greatest importance for the nutrition of animals. They supply the material for building up the tissues of the body, and for maintaining these under the wear caused by the vital functions. If present in excess, they may be used for formation of fat in the animal body, or for production of heat. This, however, is not rational feeding, as the nitrogen-free nutritive elements will do the same work, and they may be procured at less expense.

c. *Crude fiber* or *crude cellulose* is the frame work of the plants, forming the walls of their cells. It is usually the least digestible part of the plants. It is determined in the laboratory by boiling the fodder successively with a weak acid and alkali, thus dissolving out all other parts of the fodder.

d. *Nitrogen-free extract* signifies what is left of the organic matter of the plant after deducting the preceding groups of elements. It contains *starch, sugar, dextrine, gums* and similar bodies. Together with cellulose it forms the group of bodies called *carbhydrates.* They all contain the three elements, carbon, oxygen and hydrogen. A general name for carbhydrates is *heat producers;* their office in animal nutrition besides producing heat, is to assist in the formation of fat and to supply energy for the production of work. Nitrogen-free extract is determined by difference; total dry matter minus ash, ether extract, crude protein and crude fiber giving the percentage present.

TABLE I.—*Average composition of American feeding stuffs.*

FEEDING STUFFS.	No. of Analyses.	Percentage Composition.						Per Cent. of Digestible Matter.			Nutritive ratio.
		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Crude protein.	Carbhydrates.	Ether extract.	
Green fodders and silage—											
Pasture grass	....	80.0	2.0	3.5	4.0	9.7	0.8	2.6	10.6	0.5	1: 4.5
Green fodder corn (maize)	126	79.3	1.2	1.8	5.0	12.2	0.5	1.3	11.8	0.4	9.8
Green clover	43	70.8	2.1	4.4	8.1	13.5	1.1	2.9	14.1	0.7	5.4
Alfalfa (lucern)	23	71.8	2.7	4.8	7.4	12.3	1.0	3.6	11.4	0.4	3.4
Corn silage	99	79.1	1.4	1.7	6.0	11.1	0.8	1.2	11.8	0.6	10.9
Clover silage	5	72.0	2.6	4.2	8.4	11.6	1.2	2.2	10.0	0.5	5.0
Hay and dry coarse fodders—											
Clover hay	38	15.3	6.2	12.3	24.8	38.1	3.3	6.5	34.9	1.6	1: 5.9
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7	2.7	7.6	37.8	1.3	5.4
Timothy hay	68	13.2	4.4	5.9	29.0	45.0	2.5	3.0	43.9	1.2	15.5
Hay from mixed meadow grasses	11	16.0	4.6	6.4	29.9	41.0	2.1	3.6	42.7	1.0	12.5
Hay from Hungarian grass	12	7.7	6.0	7.9	27.7	49.0	2.1	4.5	46.4	1.0	10.8
Fodder corn — field cured	35	42.2	2.7	4.5	14.3	34.7	1.6	2.8	29.5	1.0	11.3
Corn stalks (stover) — field cured	60	40.5	3.4	3.8	19.7	31.5	1.1	2.0	34.1	0.6	17.7
Oat straw	12	8.7	5.2	3.8	41.5	38.9	2.2	1.6	42.8	0.7	27.7
Rye straw	8	7.7	3.8	3.5	45.3	38.4	1.4	0.7	41.4	0.4	60.4
Wheat straw	6	8.8	4.2	3.5	45.0	37.3	1.3	0.6	43.8	0.5	74.8
Buckwheat straw	3	9.9	5.5	5.2	43.0	35.1	1.3	0.9	37.8	0.5	43.2
Roots and Tubers —											
Mangolds	9	90.9	1.1	1.4	0.9	5.5	0.2	1.1	4.6	....	1: 4.4
Rutabagas	4	88.6	1.2	1.2	1.3	7.5	0.2	0.9	7.1	....	8.9
Turnips	3	90.5	0.8	1.1	1.2	6.2	0.2	0.6	5.5	....	9.2
Sugar beets	19	86.5	0.9	1.8	0.9	9.8	0.1	1.1	9.3	....	8.5
Carrots	8	88.6	1.0	1.1	1.3	7.6	0.4	1.0	7.1	....	7.1
Potatoes	12	78.9	1.0	2.1	0.6	17.3	0.1	1.4	16.1	....	11.5

Grains and grain products —											
Barley	10	10.9	2.4	12.4	2.7	69.8	1.8	9.5	66.1	1.2	1: 7.2
Oats	30	11.0	3.0	11.8	9.5	59.7	5.0	9 1	44.7	4.1	5.9
Oat shorts	1	5.5	3.9	18.1	8.9	57.3	6.2	14.1	46.2	4.5	4.0
Oat dust	2	6.5	6.9	13.5	18.2	50.2	4.8	8.9	38.4	2.8	5.0
Rye	6	11.6	1.9	10.6	1.6	72.5	1.7	8.3	65.5	1.2	8.3
Rye bran	7	11.6	3.6	14.7	3.5	63.8	2.8	9.7	48.0	1.6	5.3
Rye shorts	1	9.3	4.9	18.0	5.1	59.9	2.8	11.9	45.1	1.6	4.1
Wheat	310	10.5	1.8	11 9	1.8	71.9	2.1	9.2	61.9	1.4	7.4
Wheat bran from roller mills	7	12.0	5.6	16.1	8.4	53.7	4.2	12.6	44.1	2.9	4.0
Wheat bran — old process	9	12.0	4.9	13.0	8.1	58.2	3.8	10.1	47.5	2.6	5.3
Wheat shorts	12	11.8	4.6	14.9	7.4	56.8	4.5	11.6	45 4	3.2	4.5
Wheat middlings	33	12.1	3.4	15.7	4 7	60.2	4.0	12.2	47.2	2.9	4.4
Corn (maize)	208	10.9	1.5	10.5	2.1	69.6	5.4	7.1	62.7	4.2	10.1
Corn and cob meal	7	15.1	1.5	8.5	6 6	64.8	3.5	6.5	56.3	2.9	9.6
Corn (maize) cob	18	10.7	1.4	2.4	30.1	54.9	0.5	1.6	43.9	0.3	27.8
Corn (maize) bran	2	10.9	1.7	9.4	4.8	67.3	5.9	6.2	50.9	3.4	9.4
Buckwheat	8	12.6	2 0	10.0	8.7	64.5	2.2	7.7	49.2	1.8	6.9
Buckwheat bran	2	10.5	3.0	12.4	31.9	38 8	3.3	7.4	30.4	1.9	4.7
Buckwheat shorts	2	11.1	5.1	27.1	8.3	40.8	7.6	21.1	33.5	5.5	2.2
Buckwheat middlings	6	12.7	5.1	28.2	4.2	42.3	7.5	22.0	33.4	5.4	2.1
Pea meal	2	10.5	2.6	20.2	14.4	51.1	1.2	18.0	56.0	0.9	3.2
Sorghum seed	10	12.8	2.1	9.1	2.6	69.8	3.6	7.0	52.1	3 1	8.4
Refuse feeds —											
Malt sprouts	5	9.6	5.9	24.8	11.0	47.0	1.7	19.8	36.2	1.7	1: 2.1
Brewers' grains	15	75.7	1.0	5.4	3.8	12.5	1.6	3.9	9.5	1.3	3.2
Brewers' grains, dried	5	7.7	3.6	22.2	12.3	47.9	6.3	16.2	35.5	5.3	2.9
Germ meal	3	8.6	1.0	10.9	10.2	64.0	5.4	9.3	63.6	4.1	7.8
Gluten meal	32	9.6	0.7	29.4	1.6	52.4	7.4	25.0	49.4	5.6	2.5
Cotton seed meal	37	8.2	7.2	42.4	5.6	23.8	12.9	36.9	18.1	12.3	1.2
Cotton seed hulls	10	9.9	2.9	4.2	47.4	33.2	2.2	1.0	26.2	1.8	30.2
Linseed meal	21	9.2	5.7	32.9	8.9	35.4	7.9	27.0	32.2	7 1	1.8
Palm nut meal	....	10 4	4.3	16 8	21.0	35.0	9.5	16.0	52.6	9.0	3.4

In the foregoing table will be found the chemical composition of our common feeding stuffs. The figures given are averages of a number of analyses of each feed. The larger the number of analyses, the nearer the figures given will naturally come to the true averages. It is to be remembered, however, that, especially in the case of the coarse fodders, the chemical composition changes considerably with the maturity of the plant, the soil, the treatment of the soil, and the treatment which the fodder has received from the time of cultivation to when it is fed to the animals. The composition of a certain feeding stuff may therefore differ considerably from the average analysis. The right way to do, would be to give the variations in composition found, and leave it to the judgment of those using the table to determine what figures to choose in their particular case. As this, however, requires an intimate knowledge of the relations between soil and plants, that only few are in possession of, it is not thought advisable to do so, and only average figures are therefore given.

The quantities of the digestible portion of each fodder, as determined by numerous digestion experiments, are also given in the above table. The figures giving the composition of the fodders are in most cases the averages taken from the compilation of analyses of American fodders by *Dr. E. H. Jenkins* and *A. L. Winton, Jr.*, in *Experiment Station Record*, II, pp. 702–709; the percentages of digestible matter are calculated from the coefficients of digestibility given in the Connecticut Station Report for 1886; or from later sources where such were at hand.

The *nutritive ratio* is the proportion of digestible protein to digestible carbhydrates and fat in a ration, the percentage of fat being multiplied by 2.2 and added to the carbhydrates, as one pound of fat will produce about 2.2 times as much heat when burnt as fuel, as does one pound of carbhydrates.

Scientists have been working for more than a generation to solve the problem of the systematic feeding of farm animals. It was soon discovered that the nitrogenous bodies played an important part in the nutrition of ani-

mals, a ration containing a large proportion of these bodies giving the best results, other things being equal. As the outcome of experience gained by long continued, patient investigations, certain feeding standards were constructed, giving quantities of total dry matter, of digestible matter and the proportion of the different nutrients in the latter. This work has been done almost exclusively by German experimenters, and to these belong the honor of having first brought forward to the light the principles underlying the nutrition of farm animals.

Below are given feeding standards for farm animals, compiled by the German scientist, Dr. Emil Wolff:

Table II. Feeding Standards.—According to Wolff.
(Per day and per 1,000 lbs. live weight.)

	Total organic substance.	Nutritive (digestible) substances. Crude protein.	Carbhydrates.	Ether extract.	Total nutritive substances.	Nutritive ratio.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
1. Oxen in rest in stall	17.5	0.7	8.0	0.15	8.85	1:12.0
2. Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	11.70	1:9.0
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	13.15	1:8.0
3. Oxen moderately worked	24.0	1.6	11.3	0.30	13.20	1:7.5
Oxen heavily worked	26.0	2.4	13.2	0.50	16.10	1:6.0
4. Horses moderately worked	21.0	1.6	10.0	0.50	12.10	1:7.0
Horses heavily worked	23.0	2.5	12.1	0.70	15.30	1:5.5
5. Milch cows	24.0	2.5	12.5	0.40	15.40	1:5.4
6. Fattening oxen, 1st period	27.0	2.5	15.0	0.50	18.00	1:6.5
Fattening oxen, 2d period	26.0	3.0	14.8	0.70	18.50	1:5.5
Fattening oxen, 3d period	25.0	2.7	14.8	0.60	18.10	1:6.0
7. Fattening sheep, 1st period	26.0	3.0	15.2	0.50	18.70	1:5.5
Fattening sheep, 2d period	25.0	3.5	14.4	0.60	18.50	1:4.5
8. Fattening swine, 1st period	36.0	5.0	27.5		32.50	1:5.5
Fattening swine, 2d period	31.0	4.0	24.0		28.00	1:6.0
Fattening swine, 3d period	23 5	2.7	17.5		20.20	1:6.5
9. Growing cattle:						
Age, Months. — *Average live weight. per head.*						
2—3 — 165 lbs.	22.0	4.0	13.8	2.0	19.8	1:4.7
3—6 — 330 lbs.	23.4	3 2	13.5	1.0	17.7	1:5.0
6—12 — 550 lbs.	24.0	2.5	13.5	0 6	16.6	1:6.0
12—18 — 770 lbs.	24.0	2.0	13.0	0.4	15 4	1:7.0
18—24 — 940 lbs.	24.0	1.6	12.0	0.3	13.9	1:8.0
10. Growing sheep:						
5—6 — 62 lbs	28.0	3.2	15.6	0.8	19.6	1:5.5
6—8 — 73 lbs.	25.0	2.7	13.3	0.6	16.6	1:5.5
8—11 — 84 lbs	23.0	2.1	11.4	0 5	14.0	1:6.0
11—15 — 90 lbs.	22.5	1.7	10.9	0.4	13.0	1:7.0
15—20 — 95 lbs	22.0	1.4	10.4	0.3	12.1	1:8.0
11. Growing fat pigs:						
2—3 — 55 lbs.	42.0	7.5	30.0		37.5	1:4.0
3—5 — 110 lbs.	34.0	5.0	25.0		30.0	1:5.0
5—6 — 137 lbs	31.5	4.3	23 7		28.0	1:5.0
6—8 — 187 lbs.	27.0	3.4	20.4		23.8	1:6.0
8—12 — 275 lbs.	21.0	2.5	16.2		18.7	1:6.5

An example will readily explain the manner in which the above tables are to be used. Supposing we have at our disposal the following common feeding stuffs: fodder corn, clover hay, and bran, and that we wanted to know how much is required to keep a milch cow of 1,000 lbs. live weight in good condition and to secure a maximum yield of milk. The feeding standard for milch cows calls for 24 lbs. of total organic matter, 2.5 lbs. of digestible protein, 12.5 lbs. digestible carbhydrates, etc., and a nutritive ratio of 1:5.4. The composition of the mentioned feeding stuffs will be seen from table I. Organic matter, being what is in the fodder besides water and ash is found by subtracting the percentages of water and ash from 100. Fodder corn consequently contains 100 — (42.2 + 2.7) = 100 — 44.9 = 55.1 per cent. of organic matter; in the same way, bran (new process) is found to contain 82.4 per cent., and clover hay 78.5 per cent. of organic matter. We will now feed 14 lbs. of fodder corn, 6 lbs. of clover hay and 10 lbs. of bran. According to Table I. these quantities contain the following number of pounds of digestible matter:

	Organic matter.	Digestible.		
		Protein.	Carb hydrates.	Ether extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
14 lbs. of field-cured fodder corn	7.71	.39	4.13	.14
6 lbs. clover hay	4.71	.39	2.09	.10
10 lbs. bran	8.24	1.26	4.41	.29
Total	20.66	2.04	10.63	.53

This ration falls short of the feeding standard as regards both total organic matter and digestible substances. To bring it nearer to the standard, we shall have to add a couple of pounds of some concentrated feed. In selecting the foods and deciding the quantities to be given in each case, the market prices must be considered. We will suppose that a lot of corn meal is available in this case, and will add two pounds of this feed to the above ration:

	Organic matter.	Digestible. Crude protein.	Digestible. Carbhydrates.	Digestible. Ether extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Ration as above	20.66	2.04	10.63	.53
2 lbs of corn meal	1.75	.14	1.25	.08
Total	23.81	2.18	11.88	.61
Feeding standard	22.41	2.50	12.50	.40

The ration now corresponds fairly well with the feeding standard: there is a deficit of organic matter, and of digestible protein and carbhydrates, while digestible fat is present in excess. If the fodder corn at hand should happen to be a little drier than our average sample, as is very likely to be the case, the ration would be richer in organic matter and digestible components. The nutritive ratio (see p. 198) is found in this way:

$$.61 \times 2.2 = 1.342;\ 1.342 + 11.88 = 13.222.$$

this number divided by 2.18 (the number of pounds of digestible protein in the ration) gives 6.1; the nutritive ratio consequently is as 1:6.1. This ratio is somewhat wider than the standard according to Wolff, but will no doubt render good service nevertheless. If two pounds of bran were replaced by an equal quantity of oil meal, the ration would come very near the mark.

There is, however, no need of trying to follow the standard blindly, especially since the composition of fodders fed are apt to vary considerably.

The German scientist, Julius Kühn, advocates no definite ratio for milch cows, but says that, according to the conditions present, the lactation, yield, power of production, etc., of each cow, the nutritive ratios may profitably vary between 1:5.5 and 1:8, giving preference, however, to a ratio of 1:6 or 6.5, where Wolff puts it at 1:5.4. It would seem that the rations fed to milch cows in this state come nearer the ratio of Kühn than Wolff's standard ratio for milch cows.

In constructing rations according to the above feeding standards, several points must be considered besides the chemical composition and the digestibility of the feeding stuffs; the standards cannot be followed directly without regard to the bulk and other properties of the fodders; the ration must not be too bulky and still must contain a sufficient quantity of coarse fodder to keep up the rumination of the fodders, in case of cows and sheep, and to secure a healthy condition of the animals generally.

Further, as chemical analysis of feeding stuffs is of necessity very crude, giving only certain groups of nutritive components present, it does not reveal the inner qualities of a plant as a fodder. For instance, the plant might contain a minute quantity of alkaloids or other poisonous substances, the presence of which chemical analysis, as now generally applied to fodders, does not tell, and the plant as a consequence would not be only valueless as a fodder, but still worse, injurious to the health of the animal. This is only one of many reasons why the feeding standards and the information we gather from the composition of the fodders cannot be taken as our only guide in the feeding of our farm animals. Practical experience should go hand in hand with scientific knowledge; when this is the case, the information which may be derived from the above tables cannot help being most valuable to the feeder in aiding him to conduct his business on a rational systematic basis.

ANALYSES OF FEEDING STUFFS.

F. W. WOLL.

Owing to the high prices of our common cattle foods of late, many inquiries were received during the past season concerning various refuse feeds from mills, breweries and starch factories, from farmers who were anxious, if possible, to substitute other feeds for the high priced common feeds as oats, bran or corn meal, as food for milch cows. It was decided therefore, to enter upon an investigation of the chemical composition of some of the grain and refuse feeds that have been put on the market of late as well suited for cattle foods. Samples were procured either from the manufacturers directly or from farmers who sent in samples of feeds bought by them to learn about their composition. Twenty-six samples were received and analyzed in all, most of which feeds have been used only to a limited extent within our state until the last couple of years, and many of which it is believed are valuable feeds and well worthy of trial by the farmers of our state. The composition of some well known refuse feeds is also given in the following, having been analyzed during the past season.

(a) REFUSE FEEDS FROM BUCKWHEAT MILLS.

There is only very scant information to be found in our agricultural literature as to the chemical composition of these feeds. The investigation was therefore made as thorough as the circumstances would permit. The composition of eight samples of the products from buckwheat mills is given in the following table:

Table showing composition of feeds from buckwheat mills.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber	Nitrogen-free extract.	Ether extract.	Fine portion.
1	Buckwheat hulls...	8.84	1.91	4.12	44.81	39.63	.69	1.1
2	Buckwheat bran..	8.74	2.39	7.35	38.37	41.08	2.07	15.4
3	Buckwheat bran..	12.28	3.67	17.49	25.50	36.47	4.59	43.0
4	Buckwheat shorts.	12.28	5.31	25.92	11.80	36.93	7.76	67.9
5	Buckwheat shorts	9.97	4.95	28.19	4.77	44.66	7.46	93.6
6	Buckw't middlings	12.45	6.23	30.80	3.92	37.74	8.86	99.5
7	Buckw't middlings	9.45	5.59	29.41	3.95	43.60	8.00	96.1
8	Buckwheat flour..	14.07	.99	5.77	.37	77.90	.90	100.0

Composition of Water-free Substance.

No.		Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Total nitrogen.	Albuminoid nitrogen.	Per cent. albumenoid nitrogen.
1	Buckwheat hulls	2.10	4.52	49.16	43.46	.76	.72	.72	100.0
2	Buckwheat bran........	2.62	8.05	42.05	45.01	2.27	3.16	2.98	94.2
3	Buckwheat bran.......	4.18	19.94	29.07	41.58	5.23	1.29	1.29	100.0
4	Buckwheat shorts	6.05	29.54	13.45	42.11	8.85	4.73	4.38	92.5
5	Buckwheat shorts......	5.50	31.31	5.30	49.60	8.29	4.96	4.83	97.3
6	Buckwheat middlings...	7.12	35.18	4.48	43.09	10.12	5.63	5.46	97.0
7	Buckwheat middlings...	6.18	32.47	4.36	48.15	8.84	5.19	4.96	95.5
8	Buckwheat flour........	1.15	6.71	.43	90.63	1.05	1.07	1.00	93.4

The mechanical condition of each feed, as disclosed by the percentage passing through a sieve, 144 meshes to the square inch ("fine portion" in preceding table), stands in a direct relation to the chemical composition; starting with the coarse hulls, only 1.1 per cent. of which was fine feed, there is a steady increase in protein, ether extract and mineral matter, and a corresponding decrease in crude fiber with higher percentages of fine portion. The analysis of the buckwheat flour is given here only to make the series complete, as none of this food would be fed to cattle unless spoiled in some way.

The various operations in the milling processes and the structure of the buckwheat grain are indicated by the composition of the different products, as given above. In the milling process the hulls are first separated from the inner portions of the grain; the first analysis given shows the composition of the pure hulls. They contain only a minimum of nutrients, nearly half of their quantity being made up from cellulose or crude fiber, and about one twenty fifth of crude protein. The shorts and middlings are composed of the seed coats of the grain with the layers lying close to them, with a greater or smaller admixture of the hulls. As follows from what has been said concerning these latter, the shorts and middlings are valuable as cattle foods in an inverse proportion to the quantity of hulls they contain; with a larger proportion of hulls they are relatively less valuable than with a smaller proportion.

The high percentage of protein in the buckwheat shorts and middlings is very striking; the latter contains about twice as much protein as does wheat bran or middlings, and nearly the same quantity as oil meal. Only four analyses of buckwheat middlings are found in our agricultural literature, one from Massachusetts and four from the two Connecticut experiment stations. The average of the analyses are given below (p. 218.) The percentages of protein found were 24.65, 30.31, 22.55 and 31.25 per cent., which all are about as found in the two samples analyzed by me. We have had no experience in feeding buckwheat refuse feeds. Dr. Jenkins, of the Connecticut Station, says of the middlings, that "they are one of the cheapest and richest feeds in the market, and in the opinion of some who are using it, it is unsurpassed in favorable effect on the quality and quantity of the milk yield."

The high percentage of protein in the middlings may be caused by the germ entering into this portion in the milling process and not into the flour to any considerable extent; the rather tenaceous structure of the buckwheat germ and the comparatively low percentage of protein in the flour would seem to justify this explanation which seems further verified by microscopical examination.

With buckwheat shorts and middlings at $13 and $15, respectively, and oil meal at $22 a ton, the former feeds are considerably the cheaper ones, basing our judgment on the chemical composition of each feed; they are therefore well worthy of a careful trial. It is not till the feeds have been fed to cattle, however, and the results carefully compared, that the question of relative merits can be definitely settled.

The samples analyzed were obtained:

Nos. 1 and 5 from Emerson Lyon, Stoughton, Wis., Nos. 2 and 7 from J. G. Heaton, Reedsburg, Wis., Nos. 3, 4 and 6 from Stillman, Wright & Co., Berlin, Wis., and No. 8 from G. Munson, Livingston, Wis.

(b) REFUSE FEEDS FROM OAT MEAL FACTORIES.

Three samples were analyzed, viz.: oat shorts, "ground feed," and oat dust, all procured from the Rockford Oat Meal company, Rockford, Ill. Of these feeds, the oat dust is obtained in the first hulling operation of the kiln-dried oat grains, from the end "fuzz," with a small portion of the starchy part of the grain. The "ground feed," is a mixture of oat shorts and corn. The composition of the samples is given below, as sampled, and calculated on water-free substance.

Table showing composition of oat feeds.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Fine portion.
9	Oat shorts........	5.52	3.92	18.07	8.92	57.34	6.23	76.2
10	Ground feed.....	8.51	3.00	11.53	7.42	65.23	4.31	52.8
11	Oat dust........	5.04	6.13	14.57	15.94	52.97	5.35	94.1

Composition of Water-free Substance.

No.		Ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Total nitrogen.	Albuminoid nitrogen.	Per cent. albuminoid nitrogen.
9.	Oat shorts....	4.15	19.12	9.44	60.70	6.59	3.06	2.78	91.8
10.	Ground feed.	3.28	12.60	8.11	71.30	4.71	2.02	1.80	89.2
11.	Oat dust	6.46	15.34	16.78	55.79	5.63	2.45	2.39	97.4

Of these feed stuffs, the oat shorts are richest in protein and in ether extract. Owing to the admixture of corn (maize), the *ground feed* has a large percentage of nitrogen-free extract (starch, sugar, etc.), and a comparatively low protein content. At the prices given, it would seem that the oat dust is the cheapest feed of the three, if there should be no radical difference in the digestibility of the foods, which, however, is not likely to be the case.

(c) RYE AND CORN FEEDS.

Three samples were analyzed, viz.: rye shorts (obtained from Emerson Lyon, Stoughton, Wis.), corn bran (sent by G. H. Moore, Cerro Gordo, Ills.), and corn meal (analyzed for the Assoc. of Official Agr'l. Chemists, Washington, D. C.)

Table showing composition of rye and corn feeds.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Fine portion.
12	Rye shorts.........	9.34	4.91	18.00	5.06	59.86	2.83	87.9
13	Corn Bran...	14.06	2.03	11.79	4.28	59.98	7.86	9.1
14	Corn meal..........	11.65	1.34	9.18	3.02	71.11	3.70	....

Composition of Water-free Substance.

		Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Total nitrogen.	Albuminoid nitrogen.	Per cent. albuminoid nitrogen.
12.	Rye shorts ...	5.42	19.86	5.58	66.02	3.12	3.18	2.96	93.1
13.	Corn bran....	2.36	13.72	4.98	69.79	9.15	2.20	2.06	93.7
14.	Corn meal ...	1.51	10.39	3.42	80.49	4.19	1.66	1.61	96.6

The rye shorts are similar in composition to the oat shorts, containing about the same percentage of protein, with less of crude fiber and fat, and more of starchy substances. It is probably somewhat more valuable than the latter feed. The corn bran is a cheap refuse feed, with a fair proportion

of protein, and rich in ether extract and starchy matter, and it would seem that it is well worthy of a trial; it may usually be had at $5 per ton, but has been sold for $10 per ton during the past season of high prices for cattle foods.

(d) REFUSE FEEDS FROM BREWERIES.

Three samples were analyzed, viz.: malt sprouts, vacuum dried brewers' grains and barley feed, all of which were obtained from Pabst Brewing Company, Milwaukee, Wis. The malt sprouts are well known as a valuable feed for milch cows and fattening stock, and no description of their manufacture is needed here. The vacuum dried brewers' grains are prepared by drying the residuum of the malt after the wort has been drawn off, in a patent vacuum drying apparatus at a temperature below 130° F.; while the fresh grains contain from 75 to 80 per cent. of water, the vacuum dried grains contain only about 6 per cent. The barley feed consists of cleanings and scourings of malt sprouts, and no great claims are made for it by the manufacturers, it being sold at a nominal price. The composition of the feeds is given in the following table:

Table showing composition of refuse feeds from breweries.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Fine portion.
15	Malt sprouts...... ..	7.39	6.89	31.24	11.97	40.81	1.70	97.2
16	Brewers' grains....	6.25	3.64	29.02	16.22	36.34	8.53	86.0
17	Barley feed.........	6.31	5.55	19.27	12.88	54.33	1.66	72.5

Composition of Water-free Substance.

		Ash	Crude protein	Crude fiber	Nitrogen free extract	Ether extract	Total nitrogen	Albuminoid nitrogen	Per cent. albuminoid nitrogen.
15	Malt sprouts ..	7.44	33.74	12.93	44.06	1.83	5.40	3.87	71.5
16	Brewers' grain	3.88	30.96	17.30	38.77	9.10	4.95	4.53	91.6
17	Barley feed ..	5.92	20.57	13.75	57.99	1.77	3.29	3.07	93.5

The percentages of protein in the malt sprouts and brewers' grains are very high, and considerably higher than claimed by the manufacturers; at present prices of mill refuse foods, the given foods are undoubtedly the cheaper ones. While the malt sprouts contain more protein than do the brewers' grains, they also contain a considerably larger proportion of amide nitrogen, which would lower somewhat their nutritive value in many cases. The barley feed is shown by the analysis to be relatively rich in protein, and may be possessed of a higher nutritive value than is now supposed.

It is to be remarked, as regards the chemical composition of both these and other feeds given, that the chemical analysis of a fodder tells only of its possibilities and of the total quantity of each group of nutrients contained in it; the next question then is, how much of the nutrients contained are cattle able to utilize; this question can be definitely settled in no other way than by direct feeding trials with cattle. We may be considered justified, however, in assuming that similar products, as refuse feeds from the grains or bye products from mills, breweries, starch factories, and the like, which are used as cattle foods, do not radically differ from one another in their digestibility, so that within certain groups of feed stuffs we may take their chemical composition as an approximate indicator of their value.

(e) REFUSE FEEDS FROM GLUCOSE AND STARCH FACTORIES.

The samples given under this heading were received: No. 18 from F. M. Wilson, Selma, Ohio; No. 19 and 20 from Rockford Sugar Works, Rockford, Ill.; No 21 from S. B. Morrison, Fort Atkinson, Wis., and No. 22 from S. E. Gernon, Waukesha, Wis. All are refuse feeds from glucose or starch factories. The glucose feed, or "sugar feed" as it is sometimes called, is a wet feed that must be fed at once, to prevent its fermenting. The starch refuse constitutes the coarse portion of the corn from which most of the starch has been removed, and it is made up of the germ, gluten and hulls of the corn. It is dried by pressure and subsequent

steam drying. The gluten meal is prepared from this feed by separating the coarse hulls and germs from the finer portion, either before pressing and drying or after the process of drying. The germ meal is a refuse feed from starch factories. It has come into some prominence of late as a cattle food; the corn is heated for 8 hours at 140° F., and after a certain per cent. of starch has been taken out it is kiln-dried and ground.

The chemical composition of thefeeds is given below:

Table showing composition of refuse feeds from starch and glucose factories.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Fine portion.
18	Glucose feed.......	71.66	1.58	4.99	3.44	15.78	2.55	....
19	Gluten meal	6.93	1.43	15.75	4.61	64.26	7.02	81.7
20	Starch refuse......	7.55	1.55	13.62	8.13	60.57	8.59	57.5
21	Germ meal	6.80	1.16	10.90	9.89	66.98	4.31	....
22	Germ meal	9.87	.91	10.09	11.31	62.26	5.56	81.5

Composition of Water-free Substance.

		Ash.	Crude protein	Crude fiber.	Nitrogen free extract.	Ether extract	Total nitrogen.	Albuminoid nitrogen.	Per cent. albuminoid nitrogen.
18	Glucose feed .	5.58	17.60	12.14	55.67	9.01	2.82	2.53	89.7
19	Gluten meal..	1.54	16.75	4.95	69.20	7.54	2.71	2.71	100.0
20	Starch refuse.	1.68	14.72	8.80	65.51	9.29	2.36	2.28	96.8
21	Germ meal...	1.25	11.69	10.57	71.86	4 63	1.87	....	....
22	Germ meal ..	1.01	11.19	12.54	69.09	6.17	1.79	....	....

The composition of the dry substance of the three feeds first given in the above table shows the glucose feed to be the richest in protein, and also in crude fiber and ash. Of

the two next feeds the gluten meal contains more protein and starchy substance and less crude fiber than does the starch refuse, as would be supposed from its process of manufacture. The analyses of the samples of germ meal do not substantiate the claims made for the feed by agents, that "one ton of the germ meal is equal in feeding value to one and one-half tons of wheat bran." With its comparatively low percentage of protein and high percentage of crude fiber it is not likely to even equal this feed, and until it is proved by actual feeding trials to possess any superior nutritive effect it cannot be recommended as a cattle food in preference to bran unless its price is lower than that of the wheat bran.

(f) MISCELLANEOUS FEEDS.

Under this heading are reported the analyses of two samples of cotton seed meal, and a sample of locust bean meal and of ship stuff. The samples were obtained: No. 24 and 26 from the Association of Official Agricultural Chemists, Washington, D. C.; No. 23 from Jackson Oil Mills, Jackson, Tenn.; No. 25 from E. W. Blatchford & Co., Chicago, Ill, The locust bean meal is said to be used extensively in this country and in Europe as an ingredient of calf meals. It is the locust bean (from honey locust) ground together with the sweet pod. The following table gives the composition of the feed stuffs:

Table showing composition of feeds.

Composition as Sampled, in Per Cent.

No.		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free extract.	Ether extract.	Fine portion.
23	Cotton seed meal ..	7.31	7.10	43.66	6.12	26.79	9.02	81.6
24	Cotton seed meal...	7.43	7.65	44.93	5.25	25.27	9.42	——
25	Locust bean meal ..	9.97	2.45	5.26	6.31	75.59	.42	82.7
26	Ship stuff....... ..	11.26	5.04	17.85	9.08	52.06	4.71	——

Composition of Water-free Substance.

		Ash	Crude protein	Crude fiber	Nitrogen free extract.	Ether extract	Total nitrogen.	Albuminoid nitrogen.	Per cent. albuminoid nitrogen.
23	Cotten seed meal........	7.66	47.11	6.60	28.90	9.73	7.54	7.54	100.0
24	Cotton seed meal......	8.27	48.58	5.67	27.30	10.18	7.78	7.59	97.7
25	Locust bean meal........	2.72	5.84	7.01	83.96	.47	.93	.71	76.2
26	Ship stuff	5.68	20 15	10 23	58.63	5 31	3.22	2.98	92.4

As is well known, cotton seed meal is one of our very richest feeds, more than two-fifths of its quantity being made up of protein, with a high percentage of fat and ash, and a not very high crude fiber content. At the prices during the last season this feed is one of the cheapest concentrated foods on the market. The locust bean meal is remarkably low in everything but nitrogen-free extract, a large portion of which is sugar. Its wholesale price is given as 5½ cents per pound. Its sugar content is made its main claim to nutritive value by the manufacturers. If its chief value consists in this, the pure granulated sugar, which at the present may be had at less cost per pound, would be preferable to it as a constituent of calf meals. Johnston says of this feed (Agric. Chemistry, 14th ed., p. 424): "the beans contain merely a trace of oil, are not rich in albuminoids, but include a large proportion of sugar. They are not fitted for young animals, but are an excellent addition to food of indifferent flavor."

ON THE VALUATION OF CONCENTRATED FEEDING STUFFS.

Where chemical fertilizers are bought and sold in any quantity, a definite trade value is placed on each fertilizing ingredient; thus, for instance, for every pound of nitrogen contained in a fertilizer 17 cents may be paid, for a pound of phosphoric acid 8 cents, and for a pound of potash 6 cents, the prices fluctuating with the market. In states having fertilizer control, a guarantee must be given that

the fertilizer sold contains a definite quantity of each valuable ingredient. For feeding stuffs we have a much vaguer system, these being sold without any reference to their chemical composition, the price being determined by the supply and demand for each feed and by the reputation it may possess as a special-purpose feed. More than a generation ago, the German scientist, E. WOLFF, made the first attempt to put a money value on the different components of concentrated feeds and to determine the relative value of each group of the following nutrients: protein, fat and nitrogen-free extract (starch, sugar, etc.). For refuse feeds from flour and oil mills the relation of the cost of one pound of protein to that of one pound of fat and to one pound of nitrogen-free extract, was as 2.4: 3: 1. In later investigations by WOLFF, the figures were changed to 6: 5: 1, the calculation being based this time on the quantity of digestible components in each feed. KOENIG later on places the relation as 2.7: 2.9: 1. It will be noticed that there is a wide variation in these ratios, the protein being considered in one case more than twice as valuable as the nitrogen-free extract.

In 1878 the German Natural History Society appointed a committee to investigate the matter, and *Koenig* gives the results of their deliberations in Landw. Jahrb. IX, 805–836. The relative value of protein, fat and nitrogen-free extract was found to vary considerably from year to year with the market prices of the feeds; the valuation was decided based on the total quantity of each group of nutrients and not on their digestible matter; as average relative value for protein, fat and nitrogen-free extract during the five years 1874–79 was found 3 : 3 : 1, the absolute values in concentrated feeding stuffs being found by the "method of least squares," as follows: 1 kilo protein .335 mark, 1 kilo fat .332 mark, and 1 kilo nitrogen-free extract .109 mark. The necessity of revising these figures from time to time was recognized. Basing his calculations on market prices, 1886–89, inclusive, Koenig * found the relative value of the

* Milch Z. XVIII, 861.

three groups in fifteen common concentrated cattle foods as 3 : 2 : 1, which ratio is the most generally accepted in Germany at the present.

All these figures give a very high value to the protein compounds in the fodders, viz.: from 2.4 to 6 times as high as for nitrogen-free extract, and nearly equal or above that of fat. The method of valuation having given satisfactory results at German prices for concentrated foods, the same figures were applied to similar foods in this country, but with no great success, results being obtained that in many cases were evidently misleading. Dr. Jenkins, of the Connecticut experiment station, in 1888, went over the same ground, basing his calculations on average eastern prices for "fine feeds" (refuse feeds from flour mills, oil mills, distilleries, etc.) and found that the average retail cost of a pound of protein, fat and carbhydrates in the feed was as follows: Protein, 1.6 cents; fat, 4.2 cents; carbhydrates, .96 cents. The ratio of the cost of each group of nutrients here is as 1.7: 4.4: 1, as will be seen, a radically different relation than the one calculated from German prices.* According to eastern prices in 1890, Dr. Jenkins found the following figures for the cost of food constituents: 1 lb. protein, 1.4 cents; 1 lb. fat, 2.9 cents; 1 lb. carbhydrates, 1.4 cents, or a ratio of 1: 2.1: 1.

The prices that form the foundation for Dr. Jenkins' figures are different from our western prices, and the writer therefore went through the calculations with common western prices for the following six refuse feeds that form the main concentrated cattle foods with our farmers: Cotton seed meal, $24 per ton; linseed meal (old process), $22; wheat bran, $12; wheat middlings, $13; rye bran, $12; corn meal, $14. The calculation was based on the average chemical composition of the feeds as given by Dr. Jenkins

* The German figures are based on the content of nitrogen-free extract, while Dr. Jenkins based his calculations on the nitrogen-free extract and crude fiber; of the two methods the latter would seem preferable. (See below.) The crude fiber of the concentrated feeds has been found to possess considerable nutritive value, certainly too much to be entirely ignored. (See Journal of Landw. XXXVIII, 456–457.)

in Experiment Station Record, Vol II, No. 12. The details of the calculation are very lengthy, and only final results are therefore given here. According to average Wisconsin prices for concentrated cattle foods, we pay the following average prices for each pound of protein, fat and carbhydrates, viz.:

1 pound of protein	1.52 cents.
1 pound of fat	3.58 cents.
1 pound of carbhydrates	.47 cent.

The ratio of the cost of protein to fat and to carbhydrates is here as 3.2:7.6:1; we pay less for our concentrated feeds generally than they do in the east; the carbhydrates are the only food constituents that cost less, however, and the reduction here is so great as to make the protein and fat more expensive with us than they are in the east.

In bulletin No. 37 from Purdue University experiment station, just received, Mr. Huston gives the following values for the groups of nutrients, according to Indiana prices: 1 lb. protein 1c, 1 lb. fat 2¾c, 1 lb. carbhydrates .63c, values that lie between those of Dr. Jenkins and the writer. Taking the cost of 1 lb. of fat as the standard, we find that where they can get 2.1 pounds of protein and of carbhydrates in the east for the same money as buys one pound of fat, we get 2.4 pounds of protein and 7.6 pounds of carbhydrates for the same price as we have to pay for one pound of fat. Considering the ratios for eastern and western prices we notice that in both cases, the protein in our fine feeds costs only about four-tenths of what the fat costs, while the Germans have to pay 1½ times as much for the protein as for the fat in the same feeds.

We cannot here go deep into the application of this system of valuation; it is open to criticism on several points, and cannot be applied outside of the class of feeds that entered into the calculation of the results. It is, however, the best method at hand the judge about the economy of the various concentrated cattle foods. With the six fodders given, the valuation based on the figures obtained by the writer comes as given in the following table. To facilitate calculations, the cost of one pound of protein is placed

at 1.5 cents, of 1 lb. fat at 3.6 cents and of 1 lb. of carbhydrates at .47 cent:

	Average Wisconsin market price per ton.	Valuation.
Cotton seed meal	$24 00	$24 88
Linseed meal (O P.)	22 00	19 72
Wheat bran	12 00	13 42
Wheat middlings	13 00	13 68
Rye bran	12 00	12 76
Corn meal	14 00	12 14
Total	$97 00	$96 60

It will be noticed that the total calculated value and acttual selling price for the six feeds agree within 40 cents; considerably closer agreement would have been obtained if the costs of food constituents had been figured to hundredths of a cent.

As has already been stated the figures given under "valuation" are based upon the assumption that the crude fiber and nitrogen-free extract are of equal value in the feeds given. This is perhaps less of a mistake than it would be entirely to ignore the crude fiber of the feeds, as is done by German scientists, and the mistake is rendered of less importance on account of the fact that the content of this component in most of our concentrated feeds is rather small. The method is, however, still open to criticism on this point, and the writer therefore went through similar calculations as before with the same feeds, to find out what prices are paid for each group of nutrients. (1) protein, (2) fat, (3) nitrogen-free extract and (4) crude fiber, when the average selling price of the feeds are assumed as given above. From the six equations with four unknown quantities that are then obtained, the following values are found by the application of the method of the least squares: 1 pound of protein is worth 1.611 cents; 1 lb. of fat 3.416 cents; 1 lb. of nitrogen-free extract .476 cent and 1 lb. of crude fiber .238 cent, all according to the average Wisconsin prices as given in the preceding. Abbreviating the figures we have that in our concentrated feeding stuffs:

1 lb. protein costs	1.6 cents.
1 lb. fat	3.4 cents.
1 lb. nitrogen-free extract	.48 cent.
1 lb. crude fiber	.24 cent.

These figures agree with those previously given in placing the fat as the most valuable or, at any rate, the most costly ingredient of our concentrated foods; the relation of the cost of 1 lb. of protein to fat to nitrogen-free extract to crude fiber is as 3.3 : 7.1 : 1 : .5, that is, the protein costs three times as much as nitrogen free extract (starch, sugar, etc.) and the fat more than 7 times as much. A pouud of crude fiber, on the other hand, costs only half as much as the same quantity of nitrogen-free extract. This would show that it is erroneous to classify these two latter together, and thus giving them equal value, and it is also a mistake to leave crude fiber entirely out of consideration, as it is partly digested and assimilated by the animals. Figuring the cost of the feed given on p. 216 on basis of these values we find that the "valuation" price agrees with the market price for one ton of each of the feeds within 24 cents.

We shall now apply the figures obtained to the feeds whose composition has been given in the preceding pages. The analyses are average results taken from Dr. E. H. Jenkins and A. L. Winton's tables of Composition of American Feeding Stuffs (Experiment Station Record, Vol. II, 701–709). The following example will illustrate the manner in which the money value per ton of each feeding stuff is calculated.

Buckwheat middlings.

	Contained in 100 lbs.	Contained in a ton.	Cost per pound.	Cost per ton of feed.
	Lbs.	Lbs.	Cents.	
Protein	28.16	563.2	1.60	$9 01
Fat	7.70	154.0	3.41	5 23
Nitrogen-free extract	42.15	843.0	.48	4 05
Crude fiber	4.18	83.6	.24	20
Total value per ton				$18 49

The average composition of the feeding stuffs report ed in the preceding is given in the following table, together with their money values and market prices where these could be obtained:

Average compositian of concentrated feeding stuffs.

	No. of analyses.	Moisture.	Ash.	Crude protein.	Cr'd fiber	Nitrogen free extract.	Ether extract.	Average market price per ton.	Valuation price per ton.
Buckwheat hulls.....	3	10.14	2.05	4.62	44.66	37.65	.88	......	$7 83
Buckwheat bran.....	2	10.51	3.03	12.42	31.94	38.77	3.33	$8 00	10 58
Buckwheat shorts....	2	11.13	5.13	27.06	8.29	40.78	7.61	13 00	18 15
Buckwheat middlings	6	12.67	5.14	28.16	4.18	42.15	7.70	15 00	18 49
Oat dust	2	6.48	6.88	13.47	18 16	50.21	4.80	5 50	13 26
Oat shorts	1	5.52	3.92	18.07	8.92	57.34	6.23	11 09	17 41
"Ground feed" (oat refuse and corn)...	1	8.51	3 00	11.53	7.42	65.23	4.31	16 96	13 24
Rye shorts......	1	9.34	4.91	18.00	5.06	59.86	2.83	14 00	13 67
Corn bran.......	2	10.86	1.73	9.36	4.80	67.33	5.92	5 00	13 72
Corn meal..........	78	14.96	1.40	9.20	1.91	68.73	3.80	14 00	12 21
Malt sprouts.........	5	9.64	5.94	4.82	10.95	46.95	1.70	9 00	14 13
Dried brewers' grains	4	7.71	3.60	22.17	12.31	47.91	6.30	11 00	16 57
Barley feed.........	1	6.31	5.55	19.27	12.88	54.33	1.66	....	13 13
"Glucose feed"*....	10	65.40	.37	6.05	3.21	21.85	3.12	....	6 31
Gluten meal..........	33	9.52	.72	28.99	1.69	52.77	6.32	20.00	18 73
"Starch refuse"†....	3	8.18	1.85	13.41	9.04	58.92	8.60	....	16 23
Germ meal...........	3	8.56	1.03	10.85	10.15	63.99	5.42	17 00	13 79
Cotton seed meal.....	37	8.16	7.21	42.39	5.60	23.75	12.89	24 00	24 88
Locust bean meal....	3	10.73	2.39	5.92	6.44	73.88	.65	110 00	9 74
Ship stuff (wheat middlings)	33	12.07	3.35	15.67	4.74	60.15	4.02	13 00	13 70

* Also called "starch feed." † Also called "sugar feed."

The table presents several interesting features, both as regards the average chemical composition of the given foods and their comparative money value. It may be in order to state that the latter can be no more than a guide to judge whether or not the price of any particular fine feed is above or below the average cost of a similar food in the market. The imperfections of the method are well

illustrated in the table. Where a feed is very high in crude fiber, as in case of buckwheat hulls and bran, it does not seem probable that the crude fiber could be half as valuable as the same quantity of nitrogen-free extract (i. e. starch, sugar, gums, etc.) and these feeds may therefore be worth less than their valuation price indicates; in most of the fine feeds, the percentage of crude fiber is so small, however, that the cost of the feed is not materially affected by it. The method of judging of the commercial value of a concentrated fodder from the data given is, therefore, in the opinion of the writer, useful in making comparisons between the cost of these feeds. Their feeding value is another problem, and will depend on the combinations in which they are fed, the animals fed, and the skill of the feeder, conditions for which general rules can hardly be given.

INDIAN CORN FOR FORAGE AND FOR FIELD CORN.

F. W. WOLL AND L. H. ADAMS.

At the suggestion of Prof. F. A. Gulley, director of the Arizona Experiment Station, late of Texas, some experiments were undertaken during the season of 1890 as regards the culture of Indian corn for forage and for field corn; varieties of corn were procured from the Maryland, Kentucky, Kansas, Georgia, Texas and New York (Cornell) experiment stations, each station sending home-grown seed of the variety most prominent in its locality. All varieties were planted for forage and for field corn. The object was to compare the different varieties with one another and to learn about the total quantities of dry matter produced by each variety when grown for forage and when grown for field corn.

The soil upon which the corn was planted, was a clay loam that had been in clover the previous year. For five years previous to the season of 1890 the land had been subjected to a rotation with the following crops: corn, oats and clover. No commercial fertilizer had been used during this time; two applications of barn-yard manure were made during the five years. The land was fall-plowed and prepared for planting with a disc harrow and planker, the former loosening the surface soil from three to four inches in depth. The planker followed the harrow as soon as possible, and the land was leveled and pulverized until it was in fine enough condition to plant garden seeds. The varieties were planted on May 28th, in the afternoon, in rows 28 feet long, 8 rows being planted of each variety, 4 for forage and 4 for field corn. About twice as much seed was used as intended to be grown, in order that a perfect

stand might be secured by thinning out after the corn was safely above ground. The following table gives the varieties grown, the distance between rows and between stalks in the row:

Name of variety.	Distance between rows.	Distance between corn in the row when grown for.	
		Forage.	Field corn.
Wisconsin Yellow Dent; New York Yellow Flint	3 ft. 6 in.	6 in.	15 in.
Kansas St. Charles; Kentucky White Dent; Maryland Silver Mammoth	3 ft. 9 in.	9 in.	20 in.
Georgia Red Cob; Texas Corn	4 ft.	12 in.	24 in.

All the varieties had germinated equally strong May 31 at 2 P. M., when examined. They were all fairly up by June 3, the Wisconsin and New York varieties leading a little in the growth made. The average height of the different varieties was ascertained every tenth day during the summer. The results are given below:

Table showing average height of varieties of Indian corn during season of 1890.

Date.	Texas.	Georgia	Kansas	Kentucky.	Maryland.	New York.	Wisconsin.
(a) *Grown for forage* (Date of planting, May 28th.)							
June 7..	2.9 in.	3.3 in.	2.6 in.	3.1 in.	2.9	3.8 in.	3.1 in.
June 17.....	11.3	13.5	12.0	14.0	14.3	15.8	13.0
June 27....	25.0	32	28	29	32	32	32.5
July 7......	4.1 ft.	4.5 ft.	4.1 ft.	4.4 ft.	4.6 ft.	4.5 ft.	4.6 ft.
July 17.. ...	5.7	6.3	6.0	6.4	6.5	6.1	6.3
July 28......	7.6	8.2	7.9	8.4	8.2	6.8	7.3
Aug. 7......	8.8	9.0	9.2	9.7	9.6	7.1	7.3
Aug. 18....	9.5	9.7	9.3	9.7	10.0	....	....
Sept. 13.....	9.8	10 9	9.3	10.7	10.2	....	....
(b) *Grown for field corn* (Date of planting, May 28th.)							
June 7.......	2.3 in.	3.4 in.	3.1 in.	3.3 in.	3.3 in.	3.3 in.	3.1 in.
June 17	11.0	11.3	11.8	13.0	13.6	17.0	12.6
June 27	27.8	32.0	28.0	32.8	30.8	35.0	31.0
July 7.......	3.8 ft.	4.5 ft.	4.1 ft.	4.5 ft.	4.4 ft.	4.3 ft.	4.3 ft.
July 17......	5.0	6.4	5.7	6.5	6.1	5.6	5.7
July 28......	7.3	8.1	8.2	8.5	8.0	6.4	7.2
Aug. 7	8 0	9.5	9.2	10.2	9.3	7.0	7.3
Aug. 18......	9.1	10.0	9 9	10.2	9.3	....	....

The following extracts from the farm journal will show the amount of cultivation given the plat, and the general condition of the varieties at the different stages of growth:

June 11th. Cultivated all the varieties for the first time with a two-horse sulky cultivator.

June 18th. Cultivated with a close set harrow toothed cultivator and thinned to proper stand of stalks.

June 26–27th. Cultivated thoroughly with a close set harrow toothed cultivator, care being taken not to go so deep as to injure the roots of corn. At this time the corn is in excellent condition of growth and tilth. There have been no weeds in the corn at any time, and as there has been an abundance of rain the growth made would be considered by Wisconsin farmers an excellent one.

July 7–8th. Corn was cultivated with a four shovelled walking cultivator drawn by two horses.

July 8th. The first tassels are making their appearance with the Wisconsin and New York varieties.

July 17th. Cultivated with a one horse spring tooth cultivator. Weeds taken out of the rows by hand.

July 28th. The Pride of the North and New York varieties are in full tassel and silk. The Kansas, Kentucky and Maryland varieties show first tassel. Cultivated with a one horse narrow tooth cultivator, and weeds taken out of the rows by hand.

August 3rd. Kansas, Kentucky and Maryland varieties show first silk.

August 7th. Wisconsin and New York varieties in roasting ear. Georgia and Texas corn show first tassel.

August 10th. Maryland and Kentucky varieties in full silk.

August 18th. Kansas corn is in full silk and tassel. The Georgia and Texas corns show first silk.

September 13th. Frost threatening; hence final notes were taken previous to cutting the corn. The New York and Wisconsin varieties are the only ones that are fully matured; they are in good condition to shock at this time. The Maryland, Kentucky and Kansas varieties are fairly in milk stage, the ears are large and perfectly firm, and grained clear to the tip. The Texas and Georgia varieties are quite immature, the grain not being fully formed at the tip of the ear as yet, and at this date the silk is green on the majority of the ears.

The corn grown for forage was cut, weighed and sampled September 13; half the quantity of corn was shocked on the plats to ascertain the loss of nutrients in field-curing Indian corn. The data thus obtained will be given later in this report in our discussion of that problem. The second half was sampled and analyzed for moisture and crude protein content, with the results as given in the following table:

Table showing varieties of Indian corn grown season 1890.

(a) Grown for forage.

	Date of harvesting.	Yield	Per cent. dry matter	Per cent. protein in dry matter	Yield of dry matter.	Yield of protein	Estimated Yied per Acre. Green fodder.	Dry matter.
		Lbs.			Lbs.	Lbs.	Lbs.	Lbs.
Wis Yellow Dent	Sept. 13	249 0	32.95	9.41	82 08	7.72	27,670	9,120
N. Y. Yellow Flint..	Sept. 13	298.0	33 07	9.85	98.54	9.71	33,110	10,950
Md. Silver Mammoth	Sept. 13	474.0	24.68	8.28	116.9	9.69	49,170	12,130
Ky. White Dent...	Sept. 13	445.5	26 99	7.92	120.3	9.40	46,220	19,470
Kan. St. Charles ...	Sept. 13	481.5	24.90	7.01	119.9	8.40	49,940	12,440
Ga. Red Cob	Sept. 13	427.0	21.41	9.50	91.41	8.68	41,520	8,886
Texas Corn	Sept. 13	461 5	20.50	9.75	94.62	9.23	44,870	9,200

Considering first the dry matter in the corn grown for forage, we notice that its percentage varied from 20.5 to 33.07 per cent. The yield of fodder varied from 481.5 lbs. (Kansas) to 249 lbs. (Wisconsin). When the estimated yield of dry matter per acre is considered, the varieties will come in the following order: 1 *Kentucky;* 2 *Kansas;* 3 *Maryland;* 4 *New York;* 5 *Texas;* 6 *Wisconsin;* 7 *Georgia.* The varieties from the middle states (Maryland, Kansas, Kentucky) evidently were the most productive with us last year, and the New York variety comes next, while our own Wisconsin variety is next to the last one in the list. The question of southern against northern varieties of corn has been discussed in previous reports from this Station.* We have usually found the southern varieties yielding a somewhat larger quantity of dry matter per acre. It would seem in general that the larger varieties of corn which will mature or approach maturity with us are preferable to the extreme southern varieties. The ease of handling and the less coarse stalks of those varieties are points in their favor, so that most farmers would prefer them, even though a slightly smaller yield of nutrients per acre would be obtained.

The corn grown for field corn was cut and shocked Sep-

* Fifth Annual Report, p. 8–9. Sixth Annual Report, p. 124.

tember 13th, and left standing in the field till Oct. 21–22, when the shocks were husked and weighed, and separate samples taken of the husked shocks, and of the ears and nubbins. The following table gives the analytical data, and the yield of ears and stalks of each variety when grown for field corn:

Table showing varieties of Indian corn grown season of 1890.

(b) Grown for field corn.

	Date of harvesting.	Yield.	Per cent. dry matter.	Per cent. protein in dry matter.	Yield of dry matter.	Yield of protein.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
Wisconsin Yellow Dent	Oct. 21					
Stalks	....	38.0	65.21	7.12	24.78	1.76
Ears	....	37.25	76.52	10.38	28.49	2.96
Total	....	75.25	....	....	53.27	4.72
New York Yellow Flint	Oct. 21					
Stalks	....	81.0	43.12	9.10	34.93	3.18
Ears	....	51.75	66.39	10.94	34.34	3.76
Total	....	132.75	....	....	69.27	7.94
Maryland Silver Mammoth	Oct. 22					
Stalks	....	95.0	50.53	8.41	47.90	4.03
Ears	....	51.25	51.12	10.09	26.20	2.64
Total	....	146.25	....	....	74.10	6.67
Kentucky White Dent	Oct. 22					
Stalks	....	108.0	49.43	7.47	53.38	3.99
Ears	....	45.25	50.89	8.19	23.03	1.89
Total	....	153.25	....	....	76.41	5.88
Kansas St. Charles	Oct. 22					
Stalks	....	130.0	46.44	9 16	60 37	5.53
Ears	....	59.75	51.48	10.00	30.77	3.08
Total	....	189 75	....	....	91.14	8.61
Georgia Red Cob	Oct. 21					
Stalks	....	175.0	40.09	10.01	70.17	7.02
Ears	....	22.5	40.21	10.09	9 04	.91
Total	....	197.5	....	....	79.21	7.93
Texas Corn	Oct. 22					
Stalks	....	154 0	44.77	9.91	68 95	6.83
Ears	....	32.0	29.78	11.41	9.54	1.08
Total	....	186 0	....	....	78.49	7 91

15—Ex.

It will be noticed that the quantities of dry matter produced in this case are invariably smaller than when corn was grown for forage; the figures cannot, however, be directly compared, as the shocks had to be left standing in the field from Sept. 13th to Oct. 22nd in order to dry the ears, and doubtless some of the dry matter was lost through processes of fermentation in the meantime, as investigations conducted at this Station have fully satisfied us. In case of the varieties of corn which matured, the quantity of dry matter in the ears is about equal to that in the stalks and leaves. The more immature the variety was, on the other hand, the greater proportion of dry matter was found in the stalks; where only few and imperfect ears were found, as with the Texas and Georgia varieties, about 12 per cent. of the total dry matter in the corn was found in the ears.

LOSSES IN SILOING AND FIELD CURING INDIAN CORN

F. W. WOLL.

The work done at this Station in regard to the losses in siloing and field curing Indian corn was continued during the past season on a somewhat larger and simpler scale than heretofore. Only one silo was filled last fall, the partitions having been taken down between what was before six different small silos, making the one silo of a capacity of about eighty tons. A piece of land of eight and two-thirds acres area was planted to corn for this experiment during the season of 1890. The blue grass sod on the land the preceding year was plowed under in the fall. The varieties planted were B. & W. ensilage corn and Pride of the North Yellow Dent corn. The distance between the rows of the former variety was four feet, and of the latter three and one-half feet. The field was very long and narrow; the rows were run lengthwise, and were on an average 1,725 feet long. Fourteen of these rows were planted to B. & W. corn, and the rest to Yellow Dent corn. The corn was cut Sept. 2nd to 9th. Every other two rows were cut and weighed for the silo, while the intermediate two rows were cut and shocked at once in the field. In selecting such long rows and alternating two for the silo and two for shocked corn, it is believed that any unevenness in yield was obliterated, and the weight for the fodder put into the silo is taken for the weight of the shocked corn as well.

The silo was filled as rapidly as could be done, Sept. 2nd to 9th, about eighteen loads being cut and filled into it during each day. In filling the silo the two varieties

of corn were mixed by filling in first four or five loads of one variety, and then the same number of loads of the other. The corn was cut into three-fourths inch pieces in filling it into the silo. Separate samples were taken from every forenoon's and afternoon's fiilling, from sub-samples taken from every load of corn cut. In all 129,014 lbs. were cut for the silo. On the top of the green fodder corn 3,800 lbs. of green millet were put for a covering. The silo was opened Dec. 12th, and we began feeding from it at once. About six inches from the top layer had spoiled, otherwise the silage was good close up to the walls of the silo. The greater portion of the silage was fed out on the feeding experiment previously reported on, and samples from the same were taken once every week, so that in all seventeen samples were obtained from the silo; separate analyses were made of the same for dry matter and protein content.

The shocked fodder corn was left in the field until a little before it was needed for feeding on the experiment (Dec. 15–April 13). Most of the fodder was therefore left out during the greater part of the winter. The fall was very wet and damp, but the winter was rather dry and with much clear, sunshiny weather, so that it may be said in general that the season was favorable to this system of preserving Indian corn. The dry fodder was fed on the same experiment as was the silage, and sampled every week. The following table gives in a condensed form the total quantities of silage and of field cured fodder corn obtained from the land, and the quantities of dry matter and protein in both cases:

(a) *Siloing experiment.*

	Put into the silo.	Taken out.	Difference.	Per cent. loss.
	Lbs.	Lbs.	Lbs.	
Weight of fodder	129,014.	105.824.	....	....
Weight of dry matter	32,432	29,090.	3,342.	10.3
Weight of crude protein	2,580.5	2,557.0	323.5	12.5

(*b*) *Field curing experiment.*

	In fresh shocks.	In cured shocks.	Difference.	Per cent. loss.
	Lbs.	Lbs.	Lbs.	
Weight of fodder..........	129,014	31,738		
Weight of dry matter......................	32,432	23,270.0	9,162	28.3
Weight of protein..........	2,580.5	1,682.0	898.5	34.8

The table shows that the losses of dry matter and protein as found by us during the past year were considerably larger in the field curing than in the siloing system. The work in this line at this Station is summarized in our seventh annual report on pages 226 and 235. We found that on the average 20 per cent. of dry matter was lost in case of both systems. The reason why the losses in siloing came so much lower in last year's experiment is doubtless that a larger quantity of green fodder was siloed than ever before, viz., 65 tons. It is believed that in last year's work we have come nearer to the actual losses that take place in most of the silos of this country. Our previous experiments were never made with more than about twelve tons: the greatest quantity of corn ever put into a silo, where the losses of dry matter and protein have been determined, as far as my knowledge goes, was seventeen tons.*

For this reason the results of last year's silo work may be considered representative ones, and it is not likely that they will be materially lowered. In the silo experiment described above, 3,012 pounds of spoiled silage are calculated in with the actual decrease in weight of the silo. It was taken from the top layer, and was unfit for cattle food. With a still larger quantity siloed than 65 tons, this loss from spoiled silage may be about the same, but relatively it will count less, and the losses of dry matter and protein may therefore be slightly decreased. With more experiments conducted on the same scale, it is probable then that we shall find the losses of dry matter in the siloing process not to exceed 10 per cent. As regards the losses in

* Agricultural Science, 1890, p. 145.

field curing Indian corn, last year's results were somewhat higher than the average losses during the preceding three years, and may be accounted for by the long exposure during the fall and winter to rains and snowstorms, conditions that were in no way harder, however, than those to which the majority of our farmers subject their shocked fodder corn.

A few shocks of Indian corn were put up during last fall from the corn grown for the sake of comparison of different varieties (see p. 224). The shocks were left out for exactly three months (from September 13th to December 13th). The data, as regards the loss of nutrients, are given below:

Table showing losses of dry matter and protein in field curing fodder corn.

	Weight of shocks.		Dry matter in shocks, in pounds.				Protein in shocks, in pounds.			
	September 13.	December 13.	September 13.	December 13.	Loss.	Loss per cent.	September 13.	December 13.	Loss.	Loss per cent.
Wisconsin Yellow Dent...	87.0	31.0	30.16	27.41	2.75	9.1	2.73	2.07	.66	24.2
New York Yellow Flint...	104.0	38.0	36.59	29.46	7.13	19.5	3.41	2.41	1.00	29.3
Maryland Silver Mammoth	232.5	61.0	57.37	42.77	14.60	25.5	4.75	2.85	1.90	40.0
Kentucky White Dent. ...	212.5	67.0	57.36	48.38	8.98	15.7	4.49	2.44	2.05	45.7
Kansas St. Charles........	226.0	72.0	56.27	50.70	5.57	9.9	3.95	3.04	.91	23.0
Georgia Red Cob..	214.0	69.0	45.81	40.24	5.57	12.2	4.35	2.98	1.37	31.5
Total	.....	......	283.56	238.96	44.60	**15.7**	23.68	15.97	7.89	**33.3**

The average losses found for all the shocks are in this case 15.7 per cent. of dry matter and 33.3 per cent. of protein; these losses are somewhat lower than found in the experiment just reported, as would naturally be supposed, as the shocks in this case were left out for a shorter time. They were out in the fall, however, when we had hard rain storms and much damp weather, which would make the losses greater during this period.

If we summarize last season's work with that of the preceding three years, in the same way as was done in last year's report, we have the following table:

Average losses in siloing and field curing Indian corn.—Results of four years work.

	In original fodder.	As fed out and sampled.	Difference.	Loss. Per cent.
	Lbs	Lbs.	Lbs.	
A. *Siloing System.*				
Total quantity of —				
Dry matter	68,034 3	57,410.7	10,623.6	15.6
Protein	5,490.8	4,569.5	921.3	16 8
B. *Field Curing System.*				
Total quantity of —				
Dry matter	72,163.6	54,937	17,226.6	23.8
Protein	5,706.4	4,317.5	1,388.9	24.3

The average losses of dry matter in siloing Indian corn, according to these results, are 15.6 per cent. and in field curing the same fodder 23.8 per cent. For reasons already given, we feel inclined to believe that the former result may still be too high, owing to the small quantity of fodder siloed in previous years' experiments. Our work in this line would therefore lead us to the conclusion that the losses sustained in the field curing and field storing of Indian corn greatly exceed those in the siloing process.

SUMMARY.

1. Sixty-five tons of Indian corn siloed at this Station last fall lost 10.3 per cent. of dry matter and 12.5 per cent. of protein during the siloing period.

2. In shocking and curing a similar quantity of fodder and leaving the shocks in the field during the greater portion of the winter, 28.3 per cent. of dry matter and 34.8 per cent. of protein was lost.

3. The average losses in siloing and in field curing Indian corn, as determined during the last four years' experiments at this Station, amount to 15.6 per cent. and 16.8 per cent. for dry matter and protein, respectively, for the siloing system, and 23.8 per cent. and 24.3 per cent. for dry matter and for protein, respectively, for the field curing system.

THE CONSTRUCTION AND FILLING OF SILOS.

F. H. KING.

Silo experience in the United States now covers more than ten years, and so far as the economy of producing silage and the advantages of feeding it are concerned, there appears to be everywhere, among those who have operated successful silos, a strong conviction that good silage is a superior and cheap feed; but the same experience is now fast demonstrating serious imperfections in the construction of perhaps a majority of existing silos in this country. Some silos have so rapidly deteriorated as to become utterly useless for the purposes for which they were intended inside of three or even two years, unless they are subjected to extensive repairs, while others have never successfully preserved the materials placed in them. With a view to obviating these difficulties in the construction of future silos, and of suggesting remedies for the defects of existing ones, a study of the actual construction and condition of silos now in use has been undertaken. It is the purpose here to record some of the facts observed and to make such suggestions as the present state of the study appears to warrant.

NUMBER OF SILOS EXAMINED.

Thus far 93 silos have been examined, of which 70 are in Wisconsin, 6 in Michigan, 6 in Ohio, and 11 in Illinois. Of these, 67 are lined wholly or in part with wood; 10 are lathed and plastered with water-lime; 14 are stone, grout or brick, with cement facing; two are lined with metal, and one with tarred paper.

KINDS AND CONDITIONS OF WOOD LINED SILOS.

Of the 67 silos lined wholly or in part with wood, 34 or more than one-half, showed some rotting at the time of the examination. The oldest of these silos have been filled only five seasons; seven are rotting at the end of the second filling, and one, which was relined at the end of three years, has the new lining rotting after a single year's use. This appears like a dark record for the wood-lined silos, but there is a brighter side when the subject is studied in detail.

We have found five varieties of wood lining now in use, as follows:

1. A single layer of matched boards, of which there are two; one of these is rotting where it comes against a beam in the barn, and the other has been used one year only. In the latter of these, the silage spoiled a foot in at the corners, and from two to four inches on the sides.

2. Two layers of common boards without paper and unpainted. But one of these was examined, and this was rotting in several places after three years' service. The silage had spoiled to a considerable extent in it, but it should be said that it was built of cull boards, many of which were worm-eaten and even spongy in places.

3. Two thicknesses of boards separated by strips of furring laid upon the tarred paper. Of the six silos containing this type of lining, their average age being 3.33 years, every one has rotted, two of them so badly as to require extensive repairs before the silos are suitable for service again.

4. One thickness of matched boards with paper on the studding. Thirteen of these silos have been visited, six of which, with an average age of three years, are in good condition still, while seven, with an average age of 3.43 years, are rotting more or less.

5. Two thicknesses of boards with paper between, nailed closely and firmly together. There are 45 of these silos, 26 with an average age of three years, in good condition, while 19 with an average of 3.4 years are rotting to some extent.

The rotting which has occurred in most of the cases

noted is by no means general, and the conditions under which it has occurred may be thus stated:

1. Rotting where there has been inadequate general ventilation,— eight cases.

2. Rotting where stone walls have been faced with wood, — eight cases.

3. Rotting where boards came against beams or sills,— twelve cases.

4. Rotting where spoiled silage is left piled against the boards,— four cases.

5. Rotting where dirt is piled against or lies behind the lining,— four cases.

IMPORTANCE OF THOROUGH VENTILATION.

I believe that the rotting in every case we have thus far observed in the walls of wood silos is attributable to imperfect ventilation, and that it might have been greatly delayed if not entirely prevented by different methods of construction.

Wood kept perfectly and continuously dry, or perfectly and continuously saturated with liquids which do not act chemically upon it will resist decay for generations; while almost any natural wood, containing a suitable amount of moisture and possessing the right temperature, may rot in a very brief period provided only that there be present in it the living spores or germs which develop and multiply at the expense of the wood tissue.

The ordinary kinds of wood decay are processes of disintegration due to forms of life which develop from spores and do their destructive work where conditions are favorable, that is, where the temperature is right and the wood is, for considerable intervals of time, neither too wet nor too dry. This being true, it is evident that wood-lined silos should be so constructed that all lumber against which the silage does not lie, shall be continuously too dry to permit of decay, while the lining itself should be permitted to become dry, and remain so, as fast as the silage is removed from it. These conditions may be maintained in all comparatively dry climates I believe, by adopting modes of

construction which insure very thorough ventilation both of the silo pit and within the silo walls immediately behind the lining; but it may be seriously questioned whether in damp climates, where the shingles of houses are largely moss-covered most of the summer, a simple wood lining can last long in any silo.

It will be readily seen that the type of silo lining, No. 3, where strips of furring on tarred paper carry the boards against which the silage rests, forming closed air spaces, is a mode of construction which must necessarily maintain a damp atmosphere behind and in contact with the lining, and every one of the six cases of this type observed has rotted badly. It will be observed that the rotting in the other cases also occurs where the mode of construction or other conditions are such as to necessitate a very slow drying of the silo lining after the silage is removed.

PAINT FOR THE WOOD LINING OF SILOS.

The linings of wood silos have been treated in various ways to render them less liable to rot, and the following have been observed:

1. Linings without paint of any kind.
2. Linings painted with hot coal tar.
3. Linings painted with coal tar dissolved in gasoline.
4. Linings painted with hot coal tar mixed with pitch.
5. Linings painted with pitch alone.
6. Linings painted with linseed oil and red ochre.
7. Linings painted with linseed oil alone.

As far as can be deduced from a study the cases visited, there appears to be very little if any advantage derived from the use of the paints mentioned. Some of the very oldest wood-lined silos I find unpainted, and at the same time perfectly sound, while on the other hand the silo having apparently the best coating of paint has rotted more than any other and inside of three years.

If a perfectly impervious coat, which would remain so, could be applied to the wood lining, this would, without doubt, be of great advantage; but the coats mentioned,

applied as they have been, leave innumerable places for the silage juices to enter the wood, and when this is the case there are two ways in which the paint may actually hasten the rotting rather than retard it, thus:

1. By preventing the boards, in places, from becoming wet enough to keep the fungi from growing there while covered by the silage.

2. By holding moisture in the boards long enough after the silage is out to allow the spores to develop and destroy the wood.

It is a well established fact that painting wet or green timber hastens rather than retards decay. It is my impression that, if a wood lining is to receive any treatment whatever, some antiseptic liquid which will readily penetrate the wood and kill the spores without at the same time injuring the silage which comes in contact with it will be best. There are several antiseptics which may be used, but they should be tested before they are recommended.

STONE AND GROUT SILOS.

We have examined fourteen silos which are stone or grout and twenty-five which are stone or grout below and wood above. The masonry of nearly all of these silos is plastered with one or more coats of some variety of water-lime or cement, and where the work is well done the great majority of the testimony goes to show that the silage is just as good in contact with the masonry, or even better than against the wood.

The water-lime coating, however, is not permanent. Both the acetic and lactic acids of the silage juices act vigorously upon the lime, in all varieties of cements, dissolving it out and leaving the mortar a layer of porous sand, which is easily and deeply scarred with the fork in removing the silage and which crumbles and rubs off under the hand. When this condition is reached, the layer of cement becomes saturated with the silage juices, and if the walls are not protected from frost, it freezes and cleaves off; where this is not the case, in the older silos the

absorbed juices undergo a change, which results in the development of a very strong and disagreeable oder, which I have rarely detected in the wood silos. The quantity of juices absorbed by the porous cement is enough to develop a thick layer of mould, sometimes covering the entire walls in the poorly ventilated silos, and this, on drying, cracks and rolls up as mud does in the sun. While it is true that the acids of the silage decompose the cement of the stone silos, still the life of a single heavy coat, well put on and protected from frost, appears to be at least ten years, and with a yearly whitewashing with pure cement, I have no doubt that a single coat of plastering might last twenty to thirty years.

Where the walls of stone silos have been left rough and uneven through insufficient pointing or not plastering them, the settling of the silage develops air spaces against the walls. which result in more or less silage spoiling; this fact coupled with another, namely, that the earlier stone silos were comparatively shallow, has been, in my judgment, the chief cause of unfavorable criticism of these structures. The only serious objection I can urge against a well built stone silo is its relatively high first cost.

It should be noted, however, that whatever neutralizes the acids, especially the lactic, preventing them from reaching that per cent. which checks further fermentation, allows these changes to continue, and if the neutralizing effect of the cement extends to any considerable distance into the silo, slightly greater losses should be expected when it is used.

LATHED AND PLASTERED SILOS

Of this class of siloes I have visited ten; one has been filled four times, three, three times, and the remainder only once or twice. No one of these silos could be pronounced unqualifiedly sound at the time of my visit. Indeed one had been relined with wood after two years' service; one was being replastered in places, and three others had some of the plastering off, two of them large areas, when they

were examined. They all showed cracks and the disintegrating effects of the acids described under the stone silos. There are several very serious objections to this type of lining:

1. The springing of weak silo walls and the treading and packing of the silage tend to break the clinches and loosen the plastering.

2. The careless use of the fork in removing the silage will necessarily perforate and break away the cement.

3. The softening effect of the acids renders the coat liable to destruction from freezing and permits the silage juices to wet the lath and woodwork behind, and by holding moisture against them after the silage is removed, increases the danger of rotting. In the silo which had been relined with wood it was stated that the boards were damp when the plastering was removed a month after the silo had been emptied and that some of the boards were already rotting. The silo which had been in use four years had been whitewashed with pure water lime each season, and this appears to have nearly neutralized the acids and thus protected the lining, for the only softening in this case was near and at the bottom. Three of this class of silos visited are round, thirty feet in diameter and plastered with hair mortar to which cement was added when it was applied. Here the greater rigidity of the silo walls, the arched surface of the mortar and the hair in the clinches, all conspire to give greater permanence to the lining than in the rectangular silos, and I have no doubt that with very thorough ventilation both of the silo pit and of the walls behind the lath, together with a yearly application of cement whitewash, the lining may last a long time.

METAL, SHINGLED AND PAPER-LINED SILOS.

We have at the Experiment Station two silos lined with metal, one with sheet-iron and the other with roofing tin. They have each been in use one year, and in my judgment are not likely to prove satisfactory. None of the available metals are in themselves proof against the acids of the silage,

and it is difficult to coat them in such a way as to entirely shut off the acids. The two varieties of paint used on the linings mentioned came off quite generally and the rusting of the sheet-iron is very noticeable. Roofing tins are now mostly coated with lead, and its compounds are poisonous.

I have found it very difficult to coat sheet-iron so as to protect it, even with coal tar which the acids do not attack, because the small cavities in the surface contain air which expands with changes of temperature and blows out, leaving minute pores through which the water and acids enter and eat under the rest of the coating. There is less trouble of this sort with tin, but in either case the fork is certain to cut through the paint and expose a fresh surface to the action of the silage juices; and besides neither of them can be applied for less than $50 per thousand square feet.

I have seen but one paper-lined silo, and it is very unsatisfactory. The paper was held in place by cleats extending both up and down and horizontally. The paper was badly warped and much torn. The cleats interfere with the settling of the silage and tend to develop air spaces which cause the silage to spoil on the sides.

The two shingled silos were in a fair state of preservation, and the silage is reported to have kept well in them. In these cases cull shingles had been used at 60 cents per thousand.

Such a lining is necessarily less perfect, and, I believe, not as lasting as plain boards, and when good shingles are compared with good lumber, the lumber is cheaper.

DEPTH OF SILOS.

An ample depth of the silage is one of the first requisites of its keeping. I have visited silos 30, 34 and 36 feet deep, and all the evidence goes to show that the best silage and the least absolute waste are found in deep silos, while other conditions being the same, the poorest silage and the most waste occur in the shallow ones. My conviction is that the best silage can hardly be secured with a depth less than 24 feet unless very heavy and careful weighting is resorted

to. The importance of depth increases when clover or other loose-lying material is cut in, and such materials should, as a rule, be covered with a considerable depth of corn to insure closer packing and a more complete expulsion of entangled air.

THE IMPORTANCE OF LATERAL PRESSURE AND OF RIGID SILO WALLS.

Strong lateral or side pressure of the silage, continuously maintained, I regard of extreme importance in insuring a permanently good quality of silage along the silo walls. In the first place, if the silage is not at all times pressed firmly by the walls the high temperature of the silage maintains convection air currents between it and the walls which rapidly promote decay and this widens the air-passages so that rotting is pushed forward at an increasing rate. In the second place, which is very important, since no silo, unless it is lined so as to have water-tight joints, is really air-tight, the pressure and suction effects of the winds on the walls outside and the slow but constant diffusion of air combine with convection currents just referred to, to make the exchange of air between the inside and outside of the silo much more rapid where the silage is not pressed hard against these innumerable small openings.

On account of the facts just stated, it is important that the silo walls shall be rigid enough, not simply to withstand the lateral pressure without breaking, but to do so without being sprung outward to any considerable extent. Where the walls do yield under silage pressure, the greatest bending occurs at a point below the center, and this leaves the silage in the upper half of the silo to settle into a pit which widens downward, and this tends to leave that portion of the silage, after settling, pressing against the walls very lightly or not at all.

The strong lateral pressure necessary to good silage can not safely be secured by making the silo wider at the top and leave it shallow for then the lack of sufficient downward pressure endangers the whole silage while the flaring

sides, by increasing the dragging of the silage, makes the downward pressure less than it would be were the walls vertical.

FORM AND DIMENSIONS OF SILOS.

In form the silo should be either round or as nearly square as it is practicable to make it, because these forms give the greatest capacity with the least amount of side exposure. The long, narrow silos are needlessly wasteful, both of silage and of lumber. I have visited one silo 12x27 feet, only 12 feet deep, and another 16x48, 22 feet deep. Now a silo 32 feet square will have the same amount of side exposure as the one 16x48, and for the same depth, will hold just one-third more; while the same amount of side in a round silo will enclose more than two-thirds more silage and will require much less lumber to build it, because 2x4 studding may be used, the siding and lining acting as hoops giving the needed strength, and because both the amount of siding and of roof materials would be much less.

WEIGHT OF SILAGE PER CUBIC FOOT TWO DAYS AFTER FILLING.

The weight of silage per cubic foot, at the time of filling, is a matter which we need to know with a fair degree of precision in order to intelligently decide upon the proper dimensions for a silo. The Station silos, which are 14 feet deep, were filled this year with Pride of the North corn, a little over-ripe, to a depth of 13 feet. The silage was cut in half-inch sections and continuously tread during the filling, which lasted about one week, and had a mean weight, at the close, of 24.75 lbs. per cubic foot. In 1890, when filled to a depth of 12 ft. with the same variety of corn but greener, the mean weight was 27.9 lbs. Prof. F. E. Emery in Bulletin No. 80, North Carolina Experiment Station, mentions having filled several silos to a depth of 14 feet where the mean weight was less than 26 lbs. per cubic foot. He cites another silo 31½ feet deep filled with King Philip corn where the silage, weighed in, averaged only 34 lbs. per cubic foot, but which settled so as to average 41.8 lbs. sup-

posing no loss to have occurred. Two of the New York Experiment Station silos 14 feet deep, each filled in two days averaged when full 25.9 and 25.7 lbs. per cubic foot, but settled in $2\frac{1}{2}$ days so as to average 32 lbs. A Missouri Experiment Station silo 16 x 22, 16 feet deep, held 85 tons, making an average of 30 lbs. per cubic foot. The silage in one of the Kansas Experiment Station silos filled so as to be 20 feet deep two days after filling had an average weight of nearly 34 lbs. per cubic foot. The round silo of Mr. C. E. King, Whitewater, Wis., which is 22.75 feet inside diameter and 34 feet deep contained at the completion of filling, when the silage was 27 feet deep, 490,694 lbs., as nearly as could be determined by weighing rows in different portions of the fields and multiplying these weights by the number of rows, or a mean of 44.6 lbs. per cubic foot. In this case the corn was part flint and part a small variety of dent, both well glazed, a little dry, owing to the drought, and cut into the silo in 1 inch to 1.5 inch lengths without treading, the silage being leveled once daily.

Since the water of silage weighs about 62.4 lbs. per cubic foot and since the solid constituents are about 1.5 times heavier than water, it follows that a cubic foot of silage *may* weigh more than 62.5 lbs. With silage containing 30, 25 and 20 per cent. of dry matter, the possible weights per cubic foot are near 71.76, 70.2 and 68.64 lbs., respectively.

In the Rothamsted silo, No. 1 which is 15x13.83 ft. and 22 ft. deep, it is stated* that 217,694 lbs. of first crop clear clover containing 46,653 lbs. of dry matter were run through a chaffer into it, thoroughly tread during the operation and then weighted with 90 lbs. per sq. ft. Later the weights were removed and 46,624 lbs. of second crop clover containing 8,920 lbs. of dry matter were cut in and again similarly weighted, when the silage was found to be only 18 feet deep and to measure 3,706 cubic feet. Under these conditions, had there been no loss, the silage must have weighed 71.3 lbs. per cubic foot. Of course there had been a loss, and the figures suggest about 4.17 per cent. of the total

* Rothamsted Memoirs, vol. iv.

green weight. It is not stated how nearly full the silo was when the first crop was put in and weighted, but had it been within two feet of the top the mean weight per cubic foot must have been 52.4 lbs., and if we suppose the silo to have been full after weighting, which is improbable, the mean weight must still have been 47.7 lbs. In feeding out the silage the average weight of the upper four feet was found to be 45.5 lbs. and that of the lower four feet 59.5 lbs. with a general average of 53.6 lbs. per cubic foot.

The writer found the silage, in the round silo referred to above, to weigh, at the time of feeding, 45.2 lbs. per cubic foot at a mean depth of 12.79 feet below the level at which the silage was when filling ceased, ninety-four days earlier.

If we take the mean weight of well glazed corn silage, cut in slowly to a depth of 27 feet, at 42 lbs. per cubic foot, (which is 2.6 lbs. below that computed for the round silo cited above), the upper 13 feet as averaging 26 lbs., 45 lbs. as the weight of a cubic foot 13 feet below the surface, all of which are given above, and then assume that below this 13 foot level the weight per cubic foot increases uniformly until 63 lbs. is reached, the weight of a cubic foot of silage at different depths may be computed, and the average weight of a cubic foot also, for silos having different depths. In order that 63 lbs. may be the maximum possible weight of silage per cubic foot less than three per cent. of dry matter is demanded, and if the silage contains 20 per cent. of dry matter, a weight of 63 lbs. per cubic foot demands that there shall be more than one eighth of the space unoccupied by either water or solids. The results given below can of course be regarded only as rough approximations to what may actually occur under the varying amounts of water the corn may contain at the time it is put in, and the following table is given only because nothing more exact appears attainable with existing data:

Table showing the computed weight of glazed corn silage at different distances below the surface and the computed mean weight for silos of different depths two days after filling.

Depth of silage.	Weight of lower cu. ft. of silage.	Mean weight of silage per cu. ft.	Depth of silage.	Weight of lower cu. ft. of silage.	Mean weight of silage per cu. ft.
ft.	lbs.	lbs.	ft.	lbs.	lbs.
14	45	27.3	24	63	39.2
15	47	28.7	25	63	40.2
16	49	29.9	26	63	41.0
17	51	31.2	27	63	41.9
18	53	32.4	28	63	42.6
19	55	33.6	29	63	43.3
20	57	34.8	30	63	44.0
21	59	35.9	32	63	45.2
22	61	37.0	34	63	46.2
23	63	38.2	36	63	47.1

In the above table the numbers in the second and fifth columns show the weight of a cubic foot of silage at the several depths expressed in the first and fourth columns. Columns three and six show the mean weight of all the silage when the depths are those given in columns one and four.

INFLUENCE OF DEPTH ON THE CAPACITY OF SILOS.

It is evident from the facts given in the last section, and in the preceeding tables, that the storage capacity of silos increases more rapidly than the depth until the weight has become great enough to compress the silage to its maximum limit and that beyond this the capacity increases directly as the depth. A silo 14 feet deep will contain only about

$$14 \times 27.3 \text{ lbs.} = 382.2 \text{ lbs.}$$

for each square foot of bottom, while one 28 feet deep will contain

$$28 \times 42.6 \text{ lbs.} = 1{,}192.8 \text{ lbs.}$$

for each square foot of bottom, an amount more than three times as great. This means, for a round silo where stronger

studding are not required because of greater depth, that with the same expense for roof and the same expense for foundation and bottom, three times the amount of silage may be stored by simply doubling the height of the sides. As the sides of a round silo cost only about eight cents per square foot, the extra storage capacity of 133 tons in a silo 20 feet in diameter, and 28 feet deep, over a similar one 14 feet deep, would cost only $70.56, averaging less than 54 cents per ton. Not only is the first cost of the deep, round silo less per ton than the shallow one, but it can be filled more cheaply, for the man in the silo to tread the silage may be dispensed with, and the increased labor of raising the silage to a greater height costs less than the extra man. Further than this, the losses from spoiled and injured silage are much less in the deep than in the shallow silo, as stated before.

IMPORTANCE OF FEEDING FROM THE TOP AND THE USE OF PARTITIONS.

Silage spoils much more rapidly when fed from the sides than when fed from the top, and since the most economical construction demands the largest feeding area it follows that the feeding generally should take place from the top. Indeed, feeding from the top is the only really practicable method for the deep silos. Cutting down and feeding in sections leads to greater waste than feeding from the sides, and feeding on the slant unnecessarily increases the exposed surface of the silage. Where shallow silos must be used and at the same time the horizontal area must be large, partitions are recommended.

Where all the silage can be fed conveniently from one point and a large amount of silage must be stored, one silo with partitions is not only much cheaper but better than separate structures, because the additional corners cannot admit air from the outside when the pits are full and the round silo with partitions makes less corners than the rectangular ones do.

Two inch partitions give ample strength where the filling takes place on both sides at once. And if it is desired to

fill one pit faster than the other, temporary braces may be placed in the empty pit and removed as it is filled. I believe that two thicknesses of boards with paper between them make a better partition than the two inch plank which appear to be more commonly used.

THE DIMENSIONS OF SILOS REQUIRED TO GIVE THE PROPER HORIZONTAL FEEDING AREAS.

In the construction of silos it is very important to choose such dimensions as will give the best feeding area. The proper horizontal area of a feeding pit depends upon the amount of silage fed daily and the rate at which silage becomes seriously injured when exposed. I have not been able to collect facts enough to settle this important point. The spoiling is certainly more rapid in the shallow than in the deep silos, and more rapid with clover put in whole than when cut in.

I found, in the silo of Mr. C. E. King, on December 26, 1891, slight traces of moulding, owing to too slow feeding. The silage was being fed at the rate of about 1,780 lbs. daily from a surface of 406.7 square feet, and as the silage weighed at that level 45.2 lbs. per cubic foot the surface was being lowered at the rate of nearly 1.2 inches daily. From this it would appear that deep silos should be lowered nearly two inches daily and the shallow ones more rapidly.

With the aid of the data given in the table of the weight of a cubic foot of silage at different depths, I have calculated the dimensions for two depths of silos, one 30 feet and the other 24 feet. These particular depths have been chosen because the deeper one can readily be constructed wherever basement or two story barns are built and the second because, in my judgment, the silos 12, 14 and 16 feet deep have done as much, by the silage they have spoiled, in retarding the progress of the silos as has prejudice, and because all the evidence we have teaches that silos should be more rather than less than 24 feet deep. The feeding period has been taken at 180 days, the amount of silage fed daily at 40 lbs. per cow at the time it is cut into the silo, supposing the corn to be well glazed at the time of cutting.

This will make the daily feed, of course, some less than 40 lbs. weighed out of the silo on account of the shrinkage, but most of this is due to loss of water. The table here given must be regarded as containing only approximate data and therefore demanding judgment in its use:

Table giving inside dimensions of silos which will allow the silage to be fed down at a mean rate of about 2 or 3 in. daily, assuming 40 lbs. of silage, at time of filling, to be fed each cow daily. Capacity of each silo sufficient for 180 days.

No. of Cows.	SILO 30 FT. DEEP WITHOUT PARTITION.					SILO 24 FT. DEEP WITH PARTITION.				
	Contents.		Round, diameter in ft	Square, sides, in ft.	Mean depth fed daily.	*Contents.*		Round, diameter in ft	Square sides in ft.	Mean depth fed daily.
	Tons.	Cu. ft.			inches.	Tons.	Cu. ft.			inches.
30.....	108	4,091	15	12 x 14	2	108	5,510	17	16 x 16	3.2
40	144	6,545	16.75	14 x 16	2	144	7,347	20	18 x 18	3.2
50.....	180	8,182	18.75	16 x 18	2	180	9,184	22	20 x 20	3.2
60.....	216	9,818	20.5	18 x 18	2	216	11,020	24	22 x 22	3.2
70.. .	252	11,454	22	20 x 20	2	252	12,857	26	22 x 26	3.2
80.....	288	13,091	23.5	20 x 22	2	288	14,691	28	24 x 26	3.2
90.....	324	14,727	25	22 x 24	2	324	16,531	29.75	26 x 28	3.2
100.....	360	16.364	26.5	24 x 24	2	360	18,367	31.25	28 x 28	3.2

SMOOTHNESS OF SILO WALLS ESSENTIAL.

Whatever tends to the expulsion and exclusion of entangled air must conserve the silage, and whatever tends to leave or form cavities in which air can lodge in bulk, experience shows, leads to spoiled silage. Cross-rods, overhanging ledges and projecting stones should be avoided as they hold up the silage, forming cavities into which air collects, enabling the moulds to grow.

THE COVERING OF SILAGE.

When the feeding of the silage does not begin very soon after the completion of the filling, a good covering lessens

the waste. I have found the following practices in regard to covering:

1. Some do not cover at all, and have six to twelve inches of waste.

2. Some have used straw with no gain and possibly greater loss.

3. Many use green marsh hay cut on, and sometimes wet, with good results.

4. A few use chaff with good results.

5. One has used boards covered with eight inches of dry earth, which is used afterwards in the stables as an absorbent. Silage keeps well.

6. One used straw and weighted with stone, with poor results.

7. Some use cut marsh hay covered with plank, the cracks between plank covered with boards, and the whole weighted with stone. Little loss except at edges and corners.

8. Others use a layer of cut straw, then boards, then tarred paper and boards again. Keeps perfectly except at edges and corners.

9. Still others have used first paper, then boards, and these weighted with stone, with good results.

The testimony in regard to covering is quite discordant. Some claim good results with a given method, while with others it has failed. Some have good results one season, and very different results another with the same method. We need much more positive knowledge on this point than is now available.

Where feeding must supplement the pasture in the fall, as is very often necessary and as should generally be the practice, the silage may be fed at once from the silo and then, in properly constructed silos, there is no spoiled silage. This method was tried this year by Mr. C. E. King with perfect satisfaction.

PROTECTION AGAINST RATS.

Nine of the silos visited have been invaded by rats. They enter usually by burrowing under the foundation

walls, coming up inside even where cement has been used. But in some cases they have found entrance to the dead-air spaces, then cut holes through the linings, usually at the corners. Their destructive effects result from the admission of air to the silo, and when it is said that one man reports killing twenty-six rats in a silo, the possibilities of damage to silage by this nuisance can be appreciated.

The surest safeguard against them appears to be covering the bottom of the silo with a layer of small stones or grout, before the cement is applied. When the cement is applied directly upon the ground the action of the acids soon softens it to such an extent as to permit the rats to penetrate it without difficulty.

PROTECTION AGAINST FREEZING.

If we should be guided in the construction of silos by the general testimony in regard to the liability of silage freezing, the statement would be that very little attention need be paid to this point.

It must be borne in mind, however, that most of our silo experience has been gained during the past three years, when the winters have been exceptionally mild. Those owning older silos do speak of silage freezing, and some of the stone silos testify to the destructive effects of frost. The general verdict is that the freezing, so far as silage is concerned, is more an inconvenience than serious loss. When the frozen silage is mixed with the rest it quickly thaws, and is apparently relished as well as if it had not been frozen. All types of cemented silos must be built frost proof to prevent the cement from cleaving off; but with wood silos the construction required to preserve the silage and to protect the frame from weather, appears to be sufficient to prevent any serious freezing during all except protracted extremely cold weather.

THE LATERAL PRESSURE OF SILAGE.

This Station conducted a series of experiments. the present season to ascertain, if possible. the amount and variation of lateral pressure of silage upon the walls which confine it in order that the walls, as regards strength, may be

more intelligently constructed. The experiments were conducted at the farm of Mr. C. E. King, Whitewater, who very generously and gratuitously placed his silo at the disposal of the Station besides rendering very material aid in other ways contributing to the results secured.

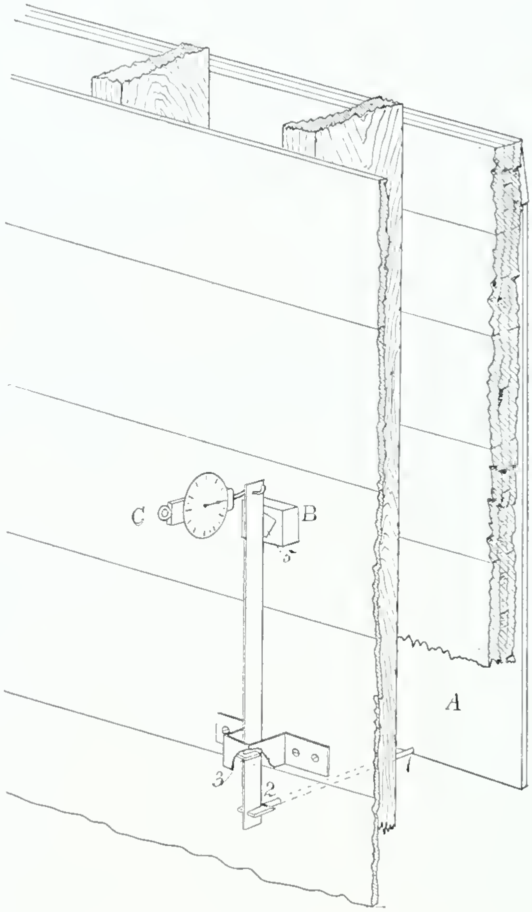

FIG. 22.

The silo in which the experiments were conducted is round, 22.75 ft. inside diameter and 34 feet deep. Fig. 22 shows the method employed for measuring the pressure from time to time as the filling progressed. Four pressure plates were used placed at different heights above the bottom of the silo and on different sides and the following table gives the observed pressure per square foot, the dates on which they were measured and the depth of silage above the center of the plates at the times the observations were made. Plate 1 had its center 3 ft. 1.5 in. above the bottom

of the silo, Plate 2, 7 ft. 5 in., Plate 3, 12 ft. 4.5 in., and Plate 4, 16 ft. 4.5 in , above the bottom.

Table showing observed pressures of silage per square foot in a round silo at the time of filling.

Date.	Plate 1.		Plate 2.		Plate 3.		Plate 4.		Remarks.
	Depth.	*Pressure.*	*Depth.*	*Pressure.*	*Depth.*	*Pressure.*	*Depth.*	*Pressure.*	
	Feet.	Lbs. per sq. ft.	Feet.	Lbs. per sq. ft.	Feet.	Lbs. per sq. ft.	Feet.	Lbs. per sq. ft.	
Sept. 3	....	....	3.83	40.00	....	....	....	....	
Sept. 7	....	....	5.83	65.00	....	....	....	....	
Sept. 8	....	....	....	72.50	....	....	....	....	
Sept. 11	15.38	150.9	11.46	125.0	6.13	62.5	2.13	15.0	
Sept. 12	14.25	150.9	10.33	132.5	5.00	67.5	1.00	15.0	Before leveling.
Sept. 12	15.75	176.9	11.83	135.0	6.50	75.0	2.50	35.0	After leveling.
Sept. 15	18.04	200.2	14.13	180.0	8.79	140.?	4.79	55.0	Noon.
Sept. 16	....	212.6	....	170.0	....	155.0	....	55.0	Morning.
Sept. 18	....	219.4	....	160.0	....	146.0	....	70.0	Before leveling.
Sept. 18	19.38	212.6	15.46	180.0	10.13	148.0	6.13	80.0	After leveling.
Sept. 19	....	222.9	....	170.0	....	146.0	....	75.0	
Sept. 22	23.88	236.6	19.96	200.0	14.63	147.5	10.63	85.0	Filling finished.
Sept. 24	....	226.3	....	207.5	....	165.0	....	86.0	
Sept. 30	21.88	212.6	17.96	190.0	12.63	133.0	8.63	95.0	

In securing these measurements the method used in mounting the plates and of connecting them with the lever to which the spring balance was applied, together with a probable error of about .2 of a pound in reading the spring balance prevented, of course, such rigid exactness as is possible in ordinary weighing. It was found impossible to determine the probable error by duplicate trials, owing to the fact that in pulling the lever until the index tin would fall, the pressure plate tended to compress the silage. so that repeated trials following one another, immediately, always gave a diminishing series of pressures, owing to the inability of the silage to at once regain its volume. I believe, however, that the probable error does not exceed 5 lbs. to the square foot.

If we divide the pressure per square foot as given in the table by the depth of silage above the centers of the several plates on the different dates, we get the results given below:

Table showing the mean pressure of silage per sq. ft. for each foot in depth of silage.

Date.	PLATE 1.		PLATE 2.		PLATE 3.		PLATE 4.	
	Depth of silage.	Pressure per foot of depth	Depth of silage.	Pressure per foot of depth.	Depth of silage.	Pressure per foot of depth.	Depth of silage.	Pressure per foot of depth.
	Feet.	Lbs.	Feet.	Lbs.	Feet.	Lbs.	Feet.	Lbs.
Sept. 3			3.83	10.43				
" 7			5.83	11.14				
" 11	15.38	9 81	11.46	10.91	6.13	10.20	2 13	7.06
" 12	15.75	11.23	11.83	11.41	6.50	11.54	2.50	14.00
" 15	18.04	11.10	14.13	12.74	....	....	4.79	11.48
" 18	19.38	10.97	15.46	11.64	10.13	14 62	6.13	13.06
" 22	23.88	9.91	19.96	10.02	14.63	10.09	10 63	8.00
" 30	21.88	9.72	17.96	10.58	12.63	10.53	8.63	11.01
Mean..	....	10.46	....	11.11	....	11.40	....	10.77

This table shows that, in the silo under experiment, the pressure increased at an approximately constant rate of about 11 lbs. for every foot in depth of silage. There are considerable variations shown in the table, it is true, but from the character of the silage, its heating and settling, and the necessarily only approximately exact method of measurement of the actual pressures, the variations as a rule, are not larger than should be anticipated. Plate I was under somewhat different conditions from those shown in Fig. 1, it being set into the wall so as to be just flush with the inner surface instead of projecting into the silo slightly as did the other three, but its readings, however, are not materially different from the others.

The corn cut into the silo was partly flint and partly one of the smaller varieties of dent, all of it being well advanced toward maturity and the lower leaves often dry or wilted on account of the drouth. The field cutting oc-

curred no faster than the corn was put in the silo, all of it being cut into sections from 1 to 1.5 inches long.

The results here reportd are much larger than those obtained by Prof. Shelton as reported in the first annual report of the Kansas Experiment Station, his average being only 3.59 lbs. for each foot in depth of silage, as compared with 10.94 lbs. in these trials. His pressure plate, however, was placed so that its lower edge came very close to the bottom of the silo, and hung from a ledge which jutted into the silo about six inches. It may be that both of these conditions contributed to his lower pressures, but the chief cause of the difference I attribute to the difference in the manner of measuring the pressure. He used a Fairbanks dynamometer which took directly more than one-half of the total pressure, the spring of the instrument acting continuously upon the silage tended to press it away from the wall just as pressure from the top forces it toward the bottom and necessarilyas the silage is pressed backward the spring would regain its unstrained attitude and the indicated pressure would be less. It was this tendency of the silage to yield under pressure, which prevented the writer, as already stated, from determining the probable error in his own method. Practical experience proves beyond a doubt that the pressures are greater than those indicated by Prof. Shelton's results, and I see no way of avoiding the conclusion that, in the case here reported the pressures were as great as the tables presented indicate, and I believe they will be found close to the truth for most cases. It should be stated in this connection, as having a possible bearing on the results obtained, that in filling the silo the silage was dropped continuously at a point near the center of the pit, and was leveled only once daily, no man being kept in the silo. It appears to the writer quite probable that this method of filling had a tendency to develop a full center down whose conical surface the silage, during heating and settling, tended to slide toward the sides and thus develop a higher pressure than might have been observed had a man been kept in the pit and the surface of the silage maintained at all times, horizontal.

CONSTRUCTION OF WOOD SILOS.

At present prices there is no available material on the market which can compare with wood in cheapness of first cost; and if a mode of construction can be devised which will insure permanency to the frame work, and at the same time give an effective service of, say, ten years to the lining, the essential demands of a material for silo-building will be met by it. The fact that we have perfectly sound all wood silos of five years' standing which embody only a portion of the principles essential to long life is encouraging for this type of construction. I believe there need be no question about the entire adequacy of the wood frame and the covering outside, above ground, and I have great hopes for the wood lining.

In the construction of a wood silo it is important to have in mind the conditions essential to durability, and some of them will be here stated:

1. Only sound and well seasoned lumber should be used. I have mentioned the case of a second lining rotting in a single season. In this case the new boards were placed directly against those which were rotting, an equivalant to adding wood to fire; and when unsound lumber is used it is very likely to contain either the spores or living fungi which only require the dampness of the silo and its warm temperature to carry forward their destruction. Sapwood, too, is much more subject to rot, because it contains more food upon which the fungi subsist: hence the sappy ends of studding should be turned up and the sappy edges outward. The soundest boards should be reserved for the lining and the very best placed at the bottom.

2. Whenever the conditions are favorable for the rotting of silage there it is quite possible for the silo lining to rot also, as my observations have shown, and since ample depth insures better silage, it may also be expected to better preserve the lining. I have not met a man who unqnalifiedly says his silage is as good in the corners as at most other places along the sides, hence I feel that rotting of the linings at these places is likely to take place, and for

this reason and because it is stronger and cheaper, the round form, wherever it can be used, is preferable to the angular silo.

3. The large number of observed cases of rotting where dirt, stone walls, beams or sills hold dampness behind the silo linings coupled with the cases of rotting which have occurred where there has been imperfect general ventilasion, show that perfect ventilation on both sides of the lining is one of the first essentials to its preservation, hence, horizontal studding and the placing of linings directly against beams or sills should be avoided as well as the lining of stone walls with wood.

Silo Linings.— In the majority of cases the best results have been associated with the lining consisting of two layers of boards with tarred paper between them, but it does not appear essential that either should be matched; they should be of uniform thickness, however, and the narrower widths are best. On account of the conditions which work for and against the rotting of linings I believe a still more effective and durable lining may be secured by painting both layers of boards *on one side only with hot coal tar boiled until it is not sticky when cold.* The tarred sides should be placed *face to face* in the silo, tarred paper between them, and I would urge the painting of the paper with cold coal tar after it is in place but *no faster* than the inner lining is put on. The coating of the boards may be readily done by boiling the tar in an iron kettle three feet in diameter letting one man slide the boards across the top while another paints them with a broom. The tar should be laid on smoothly, and the boards placed horizontally to cool. After boiling the tar down to the proper consistency, there should be enough fire only to keep the tar hot. A wide board should be at hand to throw over the top of the kettle to smother the flames in case the tar should take fire from overheating.

It would be less trouble, perhaps, to put on the first layer of sheeting and paint it, in place, with coal tar boiled until it is as thick as it will spread readily when cold. By painting the first lining and placing the paper, and painting this

just before the second layer is put on, a very impervious wall must be secured. Such a treatment of the lining would prevent the outer layer from becoming damp, allow the inner to dry more quickly after the silage is removed, besides rendering both more impervious to air and, it would seem, must be a great improvement at small expense, but only a trial for a series of years can positively settle the matter.

The Sills.— These should rest on a good stone wall, well bedded in mortar after having their under sides and inner edges painted with coal tar, as described for the lining, and they should be everywhere at least six inches above the bottom of the silo inside, and eight inches above the earth outside.

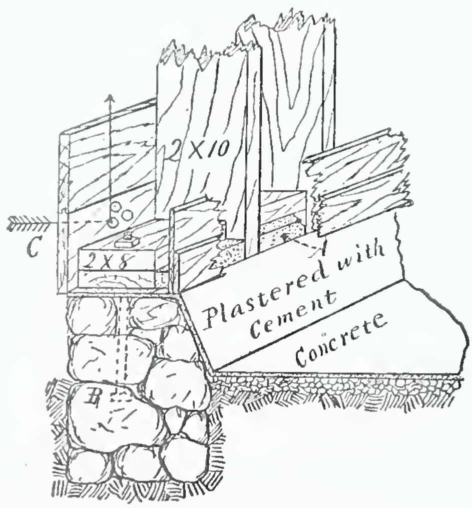

FIG. 23.—Showing the construction and ventilation of the walls of a rectangular silo. The sills are two inches narrower than the studding, to leave air space between sills and lining. A, is two inches of mortar made by stirring sand into coal tar, boiled until it is hard when cold. B, is bolt anchoring sill to wall, placed about four feet apart. C, ventilator between studding.

In the rectangular silos, where they are deep, the sills must be anchored with iron rods as shown in Fig. 23, but in the round silo this is unnecessary. Fig. 23 shows how the studding should be placed on the sills and beams, if in a barn, to insure ventilation.

COMPARATIVE EXPENSE OF DIFFERENT KINDS OF LINING FOR ROUND SILOS.

Taking 2,000 square feet of lining as the unit of comparison, we shall have the following results for different kinds of lining:

1. For all wood lining with paper and coal tar between two layers, counting fencing ripped in two $18 per M, tarred paper two cents per pound, tar $4.50 per barrel and labor $2.50 per day, we shall have:

Lumber	$36 00
Labor	7 50
Paper	8 05
Tar	4 50
	$56 05

2. For lathed and plastered lining, other items as before and lathing and plastering at 19 cents per yard, we shall have:

As above	$56 05
Lathing and plastering	42 20
	$98 25

3. For metal lining, taking other items as in No. 1, and sheet iron or tin laid on at $5.50 per square, we shall have:

As in No. 1	$56 05
Metal lining	110 00
Total	$166 05

4. Lined with brick set on edge, laid in cement and spiked to studding, counting brick $8 per M, mortar and laying $4.50 per M, one thickness of half-inch wood lining at $9.00 per M. and painting with hot coal tar inside at 5 cents per yard we shall have:

Lumber	$18 00
Carpenter labor	3 75
Paper	8 05
Brick	64 00
Mortar and laying	36 00
Painting with tar	11 10
Total	$140 90

5. Lined with wood with heavy tarred roofing felt at $4.00 per M, betweeen the linings instead of tarred paper, we shall have:

As in No. 1. less tarred paper and tar	$43 50
Roofing felt	80 00
Total	$123 50

The best qualities of heavy roofing felt would make a very impervious wall when placed between two layers of boards. The brick lining, I believe, would be practically permanent, but the lathed and plastered one I would not recommend. The difference in the first cost of a good brick lining and a good wood lining is likely to be more rather than less than that given, which is $140.90 — $56.05 = $84.85, and 5 per cent. interest on this difference is $4.24 per annum. Which would be the cheaper in the end must turn upon the relative lengths of life of the two, a matter which only time can settle.

The different kinds of lining here considered would cost some more for rectangular silos, because in them half inch lumber will not answer. Inch boards are absolutely essential for stability in these forms.

THE CONSTRUCTION OF STONE SILOS.

I have visited some very excellent stone silos in Dodge county, Wis., one of which is 14x24 inside, and 30 feet deep, 22 feet above ground. It is covered outside with dimension boards, battened, extending up and down and nailed to 2x4 studding, held in place by hooked pieces of band-irons laid in the wall; its cost was $500. There are several silos built on this general plan in the same locality, one of ten and another of seven years' standing, which have not frozen. They keep the silage excellently, but the cement is fast softening.

SIZE AND DISTANCE APART OF STUDDING IN RECTANGULAR SILOS.

The object of ascertaining the lateral pressure exerted by silage at different depths was to secure such data as would permit a use of the known laws of mechanics and the known strength of materials in computing the size of studding which may be both safely and economically used in the construction of the walls of these structures.

Starting with the assumption that the pressure of the silage increases at a rate directly proportional to the depth, which the observations given show to be at least approximately true, Prof. Wing has very kindly derived the formulas by which both the safe pressure on studding of a given size and length and the amount of bending they will suffer under it, may be calculated. The following tables have been computed from these formulas, their derivation being given beyond:

Table showing computed total pressure at time of filling upon each stud in full silos of different depths.

Depth of Silo.	Distance Between Studs.			
	12 in.	16 in.	18 in.	24 in.
	Lbs.	Lbs.	Lbs.	Lbs.
16	1408	1877	2112	2816
18	1782	2376	2673	3564
20	2200	2933	3300	4400
22	2662	3549	3993	5324
24	3168	4224	4752	6336
26	3718	4957	5577	7436
28	4312	5749	6468	8624
30	4950	6600	7425	9900
32	5632	7509	8448	11264

Table showing, for each stud in rectangular silos, the computed safe pressure, the computed actual pressure at time of filling in full silos of different depths, with studding different distances apart and the maximum amount of bending in each case, where white pine is used.

Depth of Silo.	Size of Studding.	Safe total pressure.	Computed Pressure per Stud and Amount of Bending. Distances Between Studding. 12 inches. Total pressure.	12 inches. Bending.	16 inches. Total pressure.	16 inches. Bending.	18 inches. Total pressure.	18 inches. Bending.	24 inches. Total pressure.	24 inches. Bending.
Ft.		Lbs.	Lbs.	Inches.	Lbs.	Inches.	Lbs.	Inches.	Lbs.	Inches.
16....	2x 8	1,733	1,408	1.00	1,877	....	2,112	....	2,816	....
	2x10	2.708		.52		.69		.78		1.04
	2x 8	1,541		1.83		....		....		....
18....	2x10	2,408	1,782	.94	2,376	1.25	2,673	1.40	3,564	....
	2x12	3.467		.54		.72		.81		1 08
	2x10	2,167	2,200	1.58	2.933	2.11	3,300	....	4,400	....
20....	2x12	3,120		.92		1.22		1.37		1.83
	2x10	1,970	2,662	2.55	3,549	....	3,993	....	5,324	....
22 ..	2x12	2,836		1.48		1.97		....		....
24 ...	2x12	2,600	3,168	2.28	4,224	....	4,752	....	6.336	....
			Distance Between Studding. 6 inches.		8 inches.		9 inches.		10 inches.	
	2x10	1,667	1.859	2.94	2,479	....	2,789	....	3,098	....
26 ...	2x12	2,400		1.70		2.27		2.55		2.83
28....	2x12	2,229	2,156	2.47	2,875	3.29	3.234	....	3,593	....
30....	2x12	2,080	2,475	3.48	3,300	....	3,713	....	4,125	....

The pressures given in the two preceding tables and the amount of bending in the last table should be understood as applying most closely to the studs nearest the centers of the sides of rectangular silos for in this type of structure the pressure must diminish in some undetermined ratio toward the corners where it becomes smallest. In round silos all vertical strips, of unit width, sustain uniform

pressures and in the octagonal types there is a closer approximation to this condition than in the rectangular.

The last table shows that 24 feet is the maximum depth of rectangular silo which can be constructed to advantage with 2x12 studding where these unaided must carry the lateral pressure; at this depth even, the central studding of the several sides required to be placed not more than nine inches from center to center if a flexure no greater than one inch is to be permitted.

If a bending of the studding is permitted which approaches closely to or extends a little beyond the safe elastic limit of the studs the amount of springing is likely to increase year by year, for in such cases, the form is not fully regained when the silo is emptied.

TO COMPUTE THE SAFE PRESSURE AND AMOUNT OF BENDING OF STUDDING IN WALLS OF RECTANGULAR SILOS.

PROF. CHAS. B. WING.

The following demonstration is based on the assumption that the horizontal thrust of the material in a silo against the vertical sides varies directly as the depth, when the silo is first filled and continues until the material has become thoroughly settled. Experiment seems to prove that this is nearly correct for silos of ordinary dimensions.

Our problem then is to design the studding to carry safely and without more than one inch of deflection, the loads that are liable to come upon it. We assume the case of a rectangular silo, with the studs unsupported except at the ends Each stud will have to carry a load varying uniformly as the depth, extending over its whole length and of a width equal to the distance between studs.

Let d = the unsupported length of stud,
b = the thickness of stud,
h = the width of stud,
M = bending moment or moment of flexure,
E = modulus of elasticity of the material.
I = moment of inertia $= \frac{bh^3}{12}$ for rectangular beams, placed on edge.
R = Safe stress in outermost fiber,
e = distance of outermost fiber from neutral axis of the beam.
w = horrizontal pressure for unit depth (determined by experiment),

wx = the pressure per unit of area for any depth x,

$\frac{wd}{2}$ = mean pressure per unit of area for a depth d.

$W = \frac{wd^2}{2}$ = total pressure on depth d for a vertical strip of unit width.

Let us consider a vertical strip of unit width and of depth d. From Mechanics of Materials, theory of flexure, the bending moment or moment of flexure at any point at a distance x from the top is

$$M = Px - \frac{wx^3}{6}$$ where P = the reaction at the top of the beam.

From statics $P = \frac{1}{3} W = \frac{wd^2}{6}$ therefore

$$M = \frac{wd^2}{6}.x - \frac{w}{6}.x^3 \ldots\ldots (1)$$

From Calculus to find the value of x to make M a maximum or minimum, take the first derivative of M with respect to x, equate the result equal to zero and solve for x thus:

$$\frac{dM}{dx} = \frac{wd^2}{6} - \frac{3w}{6}.x^2$$

Placing this equal to zero we have

$$\frac{w}{2}x^2 = \frac{wd^2}{6}$$ from which we have $x = \pm \frac{d}{\sqrt{3}}$

Substituting this value of x in (1) we have as the maximum moment on a beam for any depth d:

$$M = \frac{wd^3}{6\sqrt{3}} - \frac{wd^3}{18\sqrt{3}} = \frac{wd^3}{9\sqrt{3}} \ldots\ldots (2)$$

From Mechanics for safety against breaking

$$\frac{R\ I}{e} = M = \frac{wd^3}{9\sqrt{3}}$$

Substituting, $I = \frac{bh^3}{12}$ and $e = \frac{h}{2}$ the values for a rectangular beam we have:

$$\frac{R\ bh^2}{6} = \frac{wd^3}{9\sqrt{3}} = \frac{5}{39}Wd \text{ (approx)} \ldots\ldots (3)$$

or the safe load varying directly as the depth of silo is, approximately,

$$W = 1.3 \frac{R\ bh^2}{d} \quad \ldots\ldots\ldots\ldots (4)$$

To find the deflection of a beam under this form of loading we have, from theory of flexure, for any depth x and deflection y.

$$E\,I \frac{d^2y}{dx^2} = M = \frac{wd^2}{6}.x - \frac{w}{6}.x^3 \quad \ldots\ldots\ldots\ldots (5)$$

Integrating we have:

$$E\,I \frac{dy}{dx} = \frac{wd^2}{6}.\frac{x^2}{2} - \frac{w}{6}.\frac{x^4}{4} + C \quad \ldots\ldots\ldots\ldots (5)$$

Again

$$E\,I\,y = \frac{wd^2}{6}.\frac{x^3}{6} - \frac{w}{6}.\frac{x^5}{20} + C\,x + C' \quad \ldots\ldots\ldots\ldots (6)$$

For $x = 0$, $p = 0$ and therefore $C^1 = 0$ from (6). For $x = d$, $y = 0$ and from (6).

$$0 = \frac{wd^5}{36} - \frac{wd^5}{120} + Cd \text{ or}$$

$$C = \frac{wd^4}{120} - \frac{wd^4}{36} = -\frac{7}{360}wd^4$$

Substituting in (5) and equating $= 0$ we have the value of x for a maximum value of y, thus

$$\frac{wd^2}{12}.x^2 - \frac{w}{24}.x^4 - \frac{7}{360}\ wd^4 = 0$$

From which we have

$$x = \pm \frac{13}{25} d, \text{ for } y \text{ a maximum.}$$

Substituting in (6) for C and x their values as determined above we have for a maximum value of (y)

$$E\,I\,y = \frac{wd^2}{36}.\left(\frac{13}{25}d\right)^3 - \frac{w}{120}\left(\frac{13}{25}d\right)^5 + \left(-\frac{7}{360}w\,d^4.\left[\frac{13}{25}\right]\right)$$

From which

$$y = \frac{7}{540}\ \frac{Wd^3}{E\,I} \quad \ldots\ldots\ldots\ldots (7)$$

Since the load in any case is gradually applied and the sheathing offers some additional strength, we may assume $R = 1,500$ lbs. to 2,000 lbs. per square inch for white pine. Also $E = 1,500,000$ lbs. Having given the value of (w) we can at once determine the dimensions of beams for any case by assuming one value, either the breadth or thickness of beam, substitute in (eq. 4) and solve for the other dimension testing the resulting beam by (eq. 7) for deflection.

The greater the width of beam, compared to the thickness, the greater the strength for the same amount of material, thus 3″x12″ studs and 4″x9″ studs have the same amount of material in them but the 3″x12″ would carry a load, from (eq. 4),

$$W = 1.3 \frac{R}{d} .432$$

While the 4″x9″ stud would only carry a load

$$W = 1.3 \frac{R}{d} .324.$$

Studs of greater width than 12″ can not be readily obtained, and studs less than 2″ thick do not offer enough surface to nail to. Within these limits the wider the stud the better.

COST OF THREE TYPES OF SILOS COMPARED.

We give below the cost of a thoroughly built rectangular silo, and of a round one having the same capacity and depth as the stone one whose cost was $500.

In these bills the prices of materials have been set at the present local rates here, and the cost of carpenter labor has been placed sixty-five cents per M. above what I know similar work to have been done for, where the carpenters were boarded.

The mean weight of a cubic foot of silage has been taken at 44 lbs. instead of the lower figure used in computing the capacity in Bulletin No. 28.

RECTANGULAR SILO, 200 TONS.

14x24 inside, 30 feet deep.

Foundation, 13.44 perch, at $1.20	$16 13
Studding, 2x12, 28 ft., 8,736 ft., at $20.	174 72
Sills, etc., 2x10, 26 ft., 206 ft., at $19	4 94
Sills, etc., 2x10, 16 ft., 426 ft., at $14	5 96
Rafters, etc., 2x4, 20 ft., 400 ft., at $16.	6 40
Roof boards, fencing, 450 ft., at $15	6 75
Shingles, 5 M., at $3	15 00
Drop siding, 8 inch, 2,779 ft., at $16	44 46
Lining, sur. fencing, 4,256 ft., at $15	63 84
Tarred paper, 426 lbs. at 2c	8 52
Coal tar, 1 barrel	4 50
Painting, 60c. per sq	15 00
Nails and hinges	10 00
Cementing bottom	5 00
18 ¾ inch bolts, 18 inches long	2 70
Carpenter labor at $3 per M. and board	41 16
Total	$425 08

ROUND SILO, 200 TONS.

20 feet inside diameter, 30 feet deep.

Foundation, 7.5 perch, at $1.20	$9 00
Studs, 2x4, 14 & 16 ft., 1,491 ft., at $14.	20 93
Rafters, 2x4, 12 ft., 208 ft. at $14	2 91
Roof boards, fencing, 500 ft., at $15	7 50
Shingles, 6 M., at $3	18 00
Siding rabbeted, 2,660 ft., at $23	61 18
Lining, fencing, ripped, 2,800 ft., at $18	50 40
Tarred paper, 740 lbs., at 2c	14 80
Coal tar, 1 barrel	4 50
Hardware	6 00
Painting, 60c. per square	13 20
Cementing bottom	5 00
Carpenter labor at $3 per M. and board	33 17
Total	$246 59

The three silos are outside and wholly independent structures except the entrance and feeding chute shown in fig. 26, which connects with the barn. This method of connection for outside silos, while a little more costly, I feel confident, is much the best in the long run.

There is no practical difficulty in filling a silo 30 feet above the cutter. I have visited one filled 28 feet above, and several 24 feet. The carrier, of course, must be longer but the increased labor is relatively small. A filling window at a lower level may be and is in some cases provided, to be used at first.

In estimating the cost of the rectangular silo the expense has been increased $80.64 above that given in Bulletin No. 28 on account of the greater strength of studding which the observations made since the publication of that estimate show to be necessary. The estimate given in the bulletin was based upon the observed data obtained by Prof. Shelton which I now believe are too low.

Mr. A. E. Rundell of Livingston, writes that he has constructed a round silo following essentially the plan given in Bulletin No. 28, except that he covered with an octagonal roof and a square cupola. His silo is 21 feet inside diameter and 30 feet deep from plate to sill, the cost being as itemized below not including handling of lumber, sand or stone nor board of carpenter but counting his own time at one dollar per day.

Lumber	$167 00
Tarred paper, 400 lbs	8 00
Lime and mason work	10 00
Coal tar, 1 barrel	6 00
Hardware, nails, tin for roof and gutters	15 00
Cement	1 00
Labor	83 00
Total	$290 00

This is $43.50 higher than the estimate given above, but his silo is one foot larger in diameter and one foot higher above the sills. Comparing the costs per ton of silage held his cost him $1.23 and the estimate above is $1.19 per ton.

THE ACTION OF SILAGE JUICES UPON DIFFERENT VARIETIES OF HYDRAULIC CEMENT.

It was learned through a careful examination of 39 silos in which some variety of cement or common lime mortar had been used, that such linings are softened by the silage juices. To procure further evidence as to the effect of the acids found in silage upon known varieties of cement when made up with different proportions of sand, six varieties were procured upon the market for trial and each made up with sand in two proportions, one-third cement and two-thirds sand and two-fifths cement and three-fifths sand.

The cement was applied to the four sides of pieces 2 x 4 studding three feet long which had previously been covered with lath as for ordinary plastering. After standing twenty days to season, and after receiving a coat of whitewash made of the respective varieties of pure cement, to close up season checks, the two samples of each varity were placed together in barrels of water containing .0356 per cent. of lactic acid and 1.972 per cent. of acetic acid. The samples being three feet long, the upper eighteen inches of each sample was outside of the solution and served as a basis of comparison of the extent of softening by the acid.

The samples remained in the acid solution twenty-four days and the relative degree of action of the acids was determined by securing a piece of steel 1-16 inch thick and $\frac{1}{4}$

inch wide in the jaws of a heavy wrench by which it could be moved to and fro over the surface of the cements under a constant and known weight. The end of the piece of steel was filed square, held vertical to the surface of the cement and moved to and fro twenty times in the same place under a pressure of two pounds, cutting a grove $\frac{1}{4}$ of an inch wide. Four trials were made upon the portion of each sample which had been in the acid and one upon the portion outside the results of which are given below:

Table showing the amount of softening of different varieties of cement in water containing acetic and lactic acid.

Kinds of Cement.	One-third cement, Two-thirds sand.					Two fifths cement, Three-fifths sand.				
	1	2	3	4	Av.	1	2	3	4	Av.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Portland cement	.061	.057	.051	.039	.052	.020	.046	.048	.038	.038
Akron cement...	.053	.118	.055	.051	.069	.059	.049	.049	.058	.054
Louisville cement.......	.298	.284	.198	.291	.268(?)	.052	.052	.086	.055	.061
Utica cement...........	.152	.138	.110	.110	.128	.056	.068	.076	.081	.070
Buffalo cement........ .	.177	.240	.202	.160	.195	.073	.670	.110	.115	.092
Milwaukee cement......	.175	.206	.207	.167	.189	.138	.109	072	.081	.100

An accident happened to one of the Louisville samples by which the cement was broken from the end so as to allow the acid to enter along the wood and act upon both sides of the cement, and to this is due the excessive softening in this case. There was practically no abrasion of the surface of the cements by the tool where the acids had not come in contact with them and hence the relative depths to which the tool cut shows the relative resistance of the several varieties of cement to the action of the acids. It will be seen that the Portland cement had softened to the smallest depth while the Buffalo and Milwaukee had suffered most. It will also be seen that in every case the samples containing the least sand resisted the acid most thoroughly, the mean depths being .127 in. where the proportion was 1 of cement to 2 of sand and .069 in. where it was 2 of

cement to 3 of sand or only about half as great. It is evident from these results that a rich mortar should be used in the silo, and that a coat of pure cement whitewash must afford a marked protection against the acids.

ADAMANT AND ACME CEMENT.

Samples of these two varieties of plastering materials have also been tested as to the effect of acetic acid upon them. It was found that both varieties are much more permeable to water than the hydraulic cements are, and that the adamant became very soft in 38 days in a two per cent. solution of the acid. The acme cement is acted upon by the acid to some extent, but less than the Portland is. On account of its being more permeable to water than the hydraulic cements are, I hesitate to recommend its use in silos in their stead, although a practical test may show it superior to them.

CONSTRUCTION OF A ROUND SILO.

There may be a large diversity in the methods of building round silos as there is in the construction of those of the rectangular type. General directions may wisely be given here but circumstances must determine the details and specific line of procedure in every case.

THE FOUNDATION.

The foundation of the round silo as of any other form, should consist of masonry, and if the wall does not extend more than eighteen inches above the surface of the ground outside, its thickness need not exceed 12 to 18 inches. Wherever the silo is an attachment to a basement barn and where it is practicable to do so, the bottom of the silo should extend to the level of the floor upon which the stock is fed. The round silo of wood may be set upon a stone basement extending 8 or 10 feet below the surface of the ground as readily and with the same advantages as any other type. Indeed I would urge the practice generally of

sinking the bottom of the silo at least two if not three feet below the bottom of the feeding stable, wherever the ground is dry enough to prevent water from draining into it. Silage can be readily fed out from this depth and the increase of depth thus secured is very important.

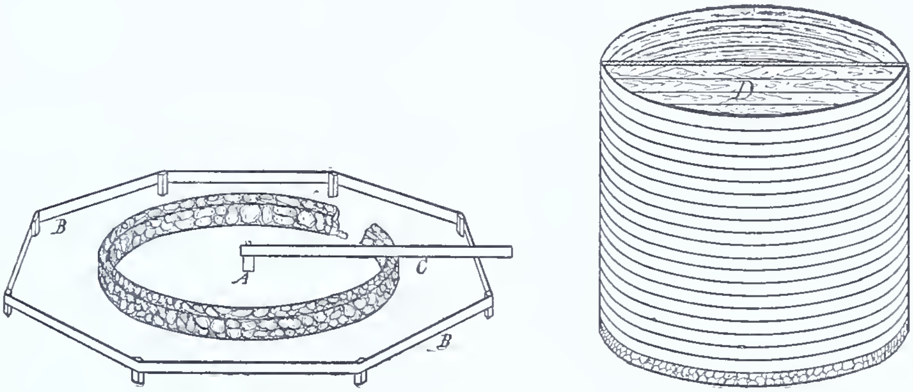

FIG. 24.—Showing method of laying and leveling foundation of a round silo, and a round silo with a single partition. A, center post with top level with top of proposed wall. B B, straight-edge boards nailed to stakes driven in ground. C, straight edge fixed to turn on a pin at A. B B, are all nailed level with top of post A. D, partition in round silo. It may be placed so as to come in the middle of the single line of doors, letting the same doors answer for both sides.

In Fig. 24 is shown one method of laying and leveling the foundation wall where it is only two to three feet high. A is a center post with top level with the top of the proposed wall. B B are boards nailed to stakes with their tops level with the top of the center post and C is a straight edge which turns on a pin at A. A simpler method is to drive down a stake like a fork handle at the center and then bore a hole through a board large enough to slip easily over the stake, then cutting this board to the length of the radius of the silo wall it can be turned about in determining the position of the outer edge of the wall. When the wall is once started it can be laid up with the plumb or level as any other wall is. In bringing the wall to a level a long straight edge may be used reaching from the center to the wall or it may be laid upon the wall directly stretching from point to point like the cord of a circle.

The top of the wall inside should be beveled so as to nearly meet the lining of the structure above as shown in Fig. 25.

THE SILLS AND PLATES.

The sills and plates are most simply made by cutting two inch lumber for the same width as the studding in sections from two to four feet long according to the diameter of the silo, sawing on the bevel determined by the direction of the radius of the circle; these, for the sills, are bedded in mortar and toe-nailed together and for the plate spiked down upon the top of the studding.

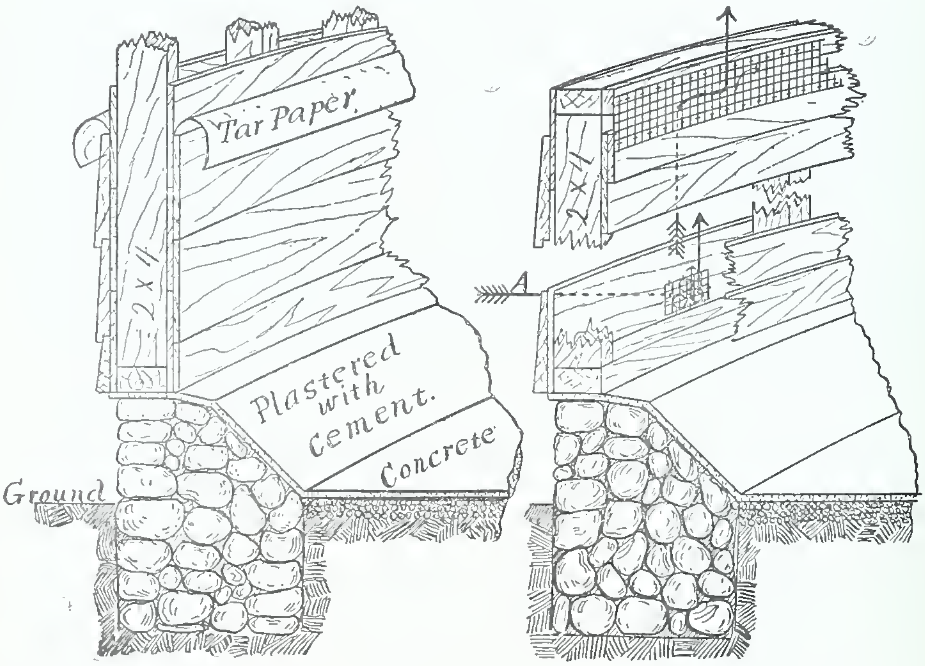

FIG. 25.—Showing the construction of all-wood round silo. Sills 2x4's cut in sections on a radius of the silo circle, bedded in mortar and toe-nailed together. Plates the same, spiked to tops of studding. Studding 2x4's one foot apart. Short lengths may be used, lapped, to get the depth. 16's and 14's will give a silo 30 feet deep. Lining made from fencing ripped in two. Outside sheeting the same. Siding for silos under 30 feet, outside diameter, common siding rabbeted; for silos more than 28 feet, outside diameter, common drop siding or ship lap may be used. A, shows ventilators between studding. Auger holes are bored at bottom between studding, and the boards lack two inches of reaching plate at top, inside. Both sets of openings are covered with wire cloth to keep out vermin. There should be a line of feeding doors from top to bottom, each 2 or 3 feet by 5 feet, and about 2.5 feet apart.

THE STUDDING.

Where the silo does not exceed 30 feet in diameter 2x 4 studding possesses ample strength and in no case is it desirable to use larger than 2x6 studding. The function of the studding is to hold the lining and siding in place and to carry the roof. The strain from the silage is sustained by

the lining and siding. The distance between the studding in silos under 30 feet in diameter should be one foot. In silos over 30 feet they may be placed 16 to 18 in. apart. If the walls of the silo above the masonry exceed 24 feet the studding may be lapped to secure the desired height.

THE LINING AND SIDING.

The lining should be of half inch lumber, and this may be obtained by splitting fencing in two or by special order at the mills. Two thicknesses with a layer of good tar paper between are required and the two layers of boards should break joints. Experience may show it desirable to use three layers of half inch lumber with two layers of tar paper between in order to secure perfect silage in contact with the wall but that layer may be added at any time should it be found desirable and for this reason I do not recommend it now.

The siding may consist of two layers with paper between where the temperature of winter demands it. Where the circle is under 30 feet half inch lumber should be used and the siding *must* be rabbeted so as to lay as shiplap does. Common house siding rabbeted answers every purpose, but it is made to order by some mills. Where the circle exceeds 30 feet in diameter drop siding may be used, that having the shiplap type being most easily put on. The nailing inside and out should be thorough and in every stud, because the boards act as hoops and the lengthwise strain comes upon the nails; for this reason also the boards should be made to break joints on the studding. For the inside lining it is better to use ten-penny nails for the last thickness so as to draw the layers tightly together, and great care should be exercised in nailing the lining not to miss the studding as every nail hole thus formed will admit a large amount of air, and this applies to all silos of whatever form.

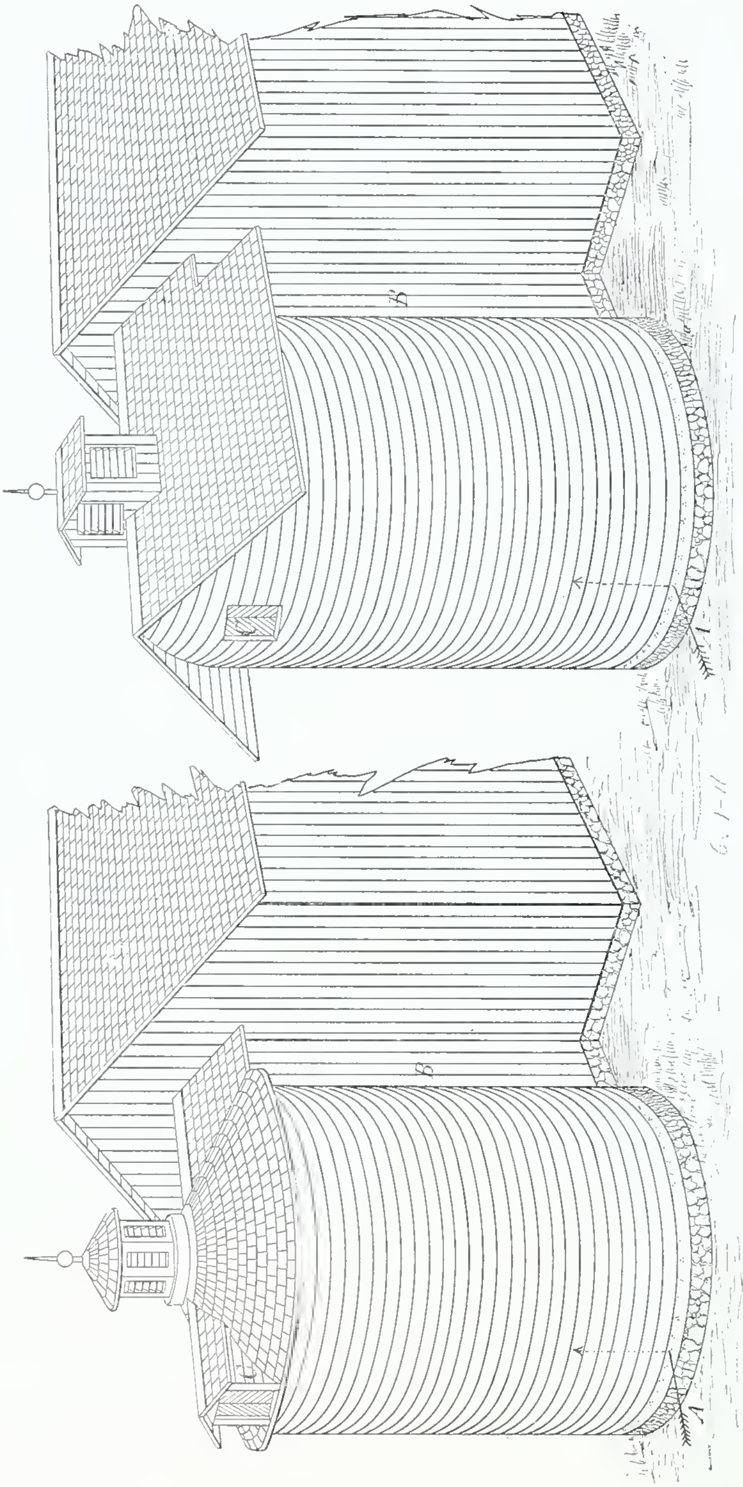

FIG. 26.—Showing two methods of roofing round silos and the manner of connecting them with a barn. A A shows where air is admitted between the studding to ventilate behind the lining. B B, the feeding chute. C C, filling window. The cupola is essential to perfect ventilation.

THE ROOF.

In Fig. 26 two styles of roofing for the round silo are shown and a method of connecting them with a barn. In the conical roof where the silo is thirty feet in diameter the rafters at the outside need not be closer together than three feet, and it is not necessary that all of these should extend to the cupola. The roof boards may be sawed to the rafters or fencing may be used extending up and down and nailed to headers. If wider boards were used in this case, they would shrink and tend to split the shingle. The octagonal type of roof may be very readily used on the round silo and where the half-round silo is built directly against the barn the shed roof may be used. The cupola, or its equivalent for ventilation is very essential. A ventilator made of galvanized iron in the form of a cylinder 2 to 2.5 feet in diameter provided with a conical hood and extending about three feet above the roof would be cheaper than a cupola and very effective. The objection to depending upon the filling-window for ventilation is that the suction effect of the wind in producing a draft is very small in this case and in damp weather the change of air would be relatively slow but the rapid drying of the uncovered lining is very important.

VENTILATION.

The method of ventilating between the studding is shown in Fig. 26. Three three-quarter inch auger holes or a single two inch one may be bored through the bottom board between each pair of studding and covered on the inside with wire netting to keep out vermin. At the top, inside, the lining lacks 1.5 to 2 inches of reaching the plate and this provides a means for a current of dry air to enter below from the outside and escape through the ventilator in the roof. The openings at the bottom outside may be provided with sliding lids held in place by a single screw in case experience shall prove that these need to be closed during very severe weather. In the rectangular silo the ventilation may be

secured in the same way or by blocking the lower board out half an inch from the sill at the lower edge or this board may be hinged so as to open and close.

THE DOORS.

There should be a line of openings from top to bottom one above the other two or three feet wide and four or five feet high separated by about three feet. These may be closed by swinging doors or with pieces of boards. Swinging doors are best made of two thicknesses of matched fencing placed at right angles to each other with paper between and thoroughly nailed to strong cleats. When closed the doors should be flush with the inner lining. The joint around the doors may be made tight at the time of filling by tacking narrow strips of tar paper over them all the way around.

CONSTRUCTION OF RECTANGULAR SILOS.

One method of anchoring the sills to the walls and of providing for ventilation between them and the lining is shown in Fig. 23. It will be seen that the sills are narrower than the studding and this is important to prevent the lining from rotting where it covers them. The plate may also be narrower to provide an escape for the air above. Instead of bolts for anchoring the sills to the wall some have used sections of cedar posts built into the wall and the sills are spiked down upon these. Where silos are built inside of barns it is very important to use such a width of studding as will permit of an air space between the silo lining and the sills and beams, otherwise rotting is certain to occur at these places as practical experience has abundantly proved.

THE FILLING OF SILOS.

RACK FOR ENSILAGE CORN.

Until a corn harvester shall be put upon the market which will cut and at the same time elevate the corn and deliver it upon the wagon, low down racks will be found

more economical than the high ones now more generally in use. One of the low-down types used at this Station the past season is represented in Fig. 27. These racks not only dispense with a man upon the wagon in loading but they materially lighten the labor of the man who takes the corn from the gavels for it is only the top of the load which need be raised shoulder high; again, when it comes to unloading the man can stand on the floor and simply draw the corn toward him and lay it upon the table of the cutter without stooping over and without raising the corn up to again throw it down.

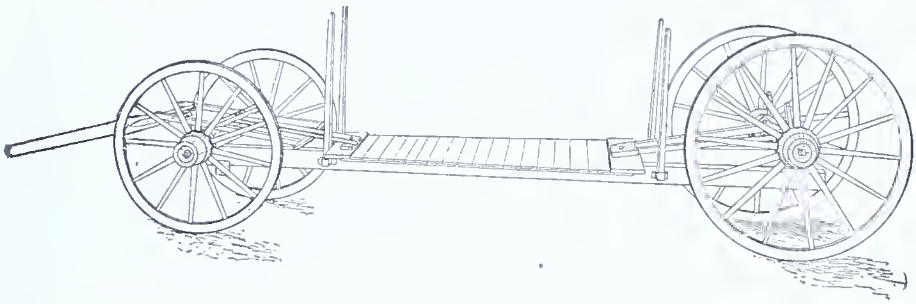

FIG. 27.—Showing low-down rack for handling silage corn. The two stringers are 4x8's, 18 or 20 feet long, swung from the front axle tree by a lengthened king-bolt provided with nut and washer; and from the hind axletree by three-quarter inch rods provided with nut and washer below and with hook above which hang from the bolster. The stringers are about 20 inches apart, outside measure, in front, and a short reach keeps the hounds from tipping up.

AMOUNT OF LABOR REQUIRED TO PUT CORN INTO THE SILO.

It is proposed here to record some observations, made during the past season, in regard to the amount of labor required to put corn into the silo. The data collected, thus far, lack both the volume and the exactness which the importance of the subject demands, but they illustrate present farm methods and furnish an approximate estimate of the amount of labor required in the cases cited.

PUTTING CORN INTO THE SILO CUT.

No. 1. Between August 31 and September 9, Mr. A. E. Fryer, near Whitewater, put into his silo 120 loads of B. & W. corn with four men, two teams, a tread power and three wagons. His method was as follows: His men went into the field and cut six rows of corn into large shocks which were placed in rows, both ways, so that a wagon might be left between two shocks of contiguous rows for loading.

After corn enough had been shocked for one or more day's filling, one team was put into the tread power, one team and man moved the three wagons to and from the field, a second man remained in the field loading the empty wagon, a third laid the corn upon the cutter while the fourth did the feeding. Two shocks of corn. one of which I found by trial to weigh 820 lbs., constituted a load, and they were placed upon the common flat hayracks. The silo stood very near the side and a little nearer one end of a seven acre field having rows about 60 rods long so that the haul was as short as it could well be.

Taking the weight of the shock cited as the average of those in the field the 120 loads would weigh 98.4 tons.

Counting the time by hours and each team the same as one man the aggregate time required to shock and put the 98.4 tons into the silo was 332.5 hours or an average of 2.96 tons of silage for each 10 hours of labor. No man was kept in the silo but they stopped at intervals to level and tread the silage.

No. 2. On the farm of Mr. C. E. King, the silo was filled with the aid of three teams, three wagons, three men, and a sweep power. The three men with the teams went to the field together and one team and man were put upon a self-rake reaper and cut corn while the other two men, each with a team, loaded the wagons. When the wagons were loaded the whole crew went to the silo and the three teams were put upon the power, one man driving while the other two put the corn through the cutter.

The racks were of the low-down type shown in Fig. 27 made by simply swinging two long poles under the axletrees by means of chains and upon which boards were placed and into which stakes were set. During the last part of the filling a girl 11 years old drove the team while cutting, and one of the other teams was divided, each horse taking a wagon, allowing the three loads to be put on by the three men at the same time. As stated elsewhere, about 245.34 tons, partly flint and partly a small dent were put in in 21 days. The average distance of the centers of

the corn fields must have exceeded 80 rods in this case and the ground cut over was a little more than 40 acres, the yield not being more than half an average crop. No man was kept in the silo, the silage being leveled once daily. Counting the time as in the former case, 942 hours were required to put in the 245.34 tons, making an average of 2.6 tons for each ten hours of labor. The time of the little girl is omitted in this estimate as it could not be determined accurately.

No. 3. On the farm of Mr. Peter McGeock, of Aztalan, I found a theshing engine driving the cutter, two men and teams with three wagons hauling, two men at the cutter, three men, and part of the time four, in the field cutting and one tending the engine. They were working ten hours per day and the foreman stated that they averaged twenty-fonr and twenty-five loads daily. While I was there they cut into the silo three loads of B. & W. corn in fifty-five minutes. They were hauling on very high flat racks and I estimate their loads to average not far from 2,200 lbs each. Taking this weight and twenty-five loads per day and the engine as three teams, corn was being put in at the rate of 2.43 tons for each ten hours of labor.

No. 4. On the farm of W. H. Phillips, of Lake Mills, there were four cutters in the field, two men each with teams hauling, one man and two teams on a sweep power and one man at the cutter. Mr. Phillips, at my request, weighed one of the loads as it came up; it was a large dent corn and weighed 2,125 lbs. At the rate they were working while I was present they would put in twenty-five loads in nine hours which is at the rate of 2.46 tons for each ten hours of labor. The haul was short but the corn was loaded onto high racks.

PUTTING CORN INTO THE SILO WHOLE.

On the farm of Mr. Wm. Marshall, Whitewater, I found four men with one team and one wagon putting flint corn into a silo whole, the haul being a short one. The men went into the field in the morning and cut until 9 or 10

o'clock, cutting three rows together, laying the corn in bundles, tops one way, and the next three rows with the tops in the opposite direction so that a wagon could be driven between them. After this three men put on the load while the fourth continued cutting until the load was on when all four men went to the silo with the team to unload. The rack was a special one made like a wood rack with removable stakes. In loading for the silo trip ropes were used; a man on the wagon removed all stakes except the two pair in front, a rope was laid down and corn enough handed up by the two men on the ground and placed between the stakes to make a load for a horse to raise in the manner of handling hay with ropes and track. This bundle was then bound with the trip rope and a second bundle formed between the same stakes. Two other stakes were then set up and the process repeated until the load was completed. At the barn a boy drove the horse which elevated the corn into the silo and three of the men went into the silo to distribute and pack the corn while one remained upon the wagon to manage the unloading. In the silo, with the aid of a sharp spade and a heavy tamping stick the corn was carefully packed along the sides and forced, by cutting with the spade, to occupy the corners closely.

It was stated that from six to seven loads were put into the silo each day of eight hours. The loading which I witnessed required twenty-five and thirty minutes after the team was in the field and the unloading fifteen and sixteen minutes after the horse was hitched to the rope. It required fifty-five minutes from the time the team began loading in the field until it returned to the field again. I have no exact measure of the loads, but they contained twelve bundles and I judge could not have exceeded 2,400 lbs. Taking seven loads per day of this weight the corn was being put into the silo whole at the rate of 2.1 tons for each ten hours of labor, omitting the boy and horse used in unloading.

If we bring these results into a table they will appear as given below:

Table of comparative costs of filling silos.

	Tons per 10 hrs. labor.	Power used.	Kind of corn.	Distance hauled.
No. 1	2.96	2-horse tread	B. & W.	Short.
No. 2	2.60	6-horse sweep	Flint and dent	Long.
No. 3	2.43	Engine	B. & W.	Medium.
No. 4	2.45	4-horse sweep	Large dent	Short.
Average	2.61 tons per ten hours with corn cut in.			
One case	2.1 tons per ten hours with corn put in whole.			

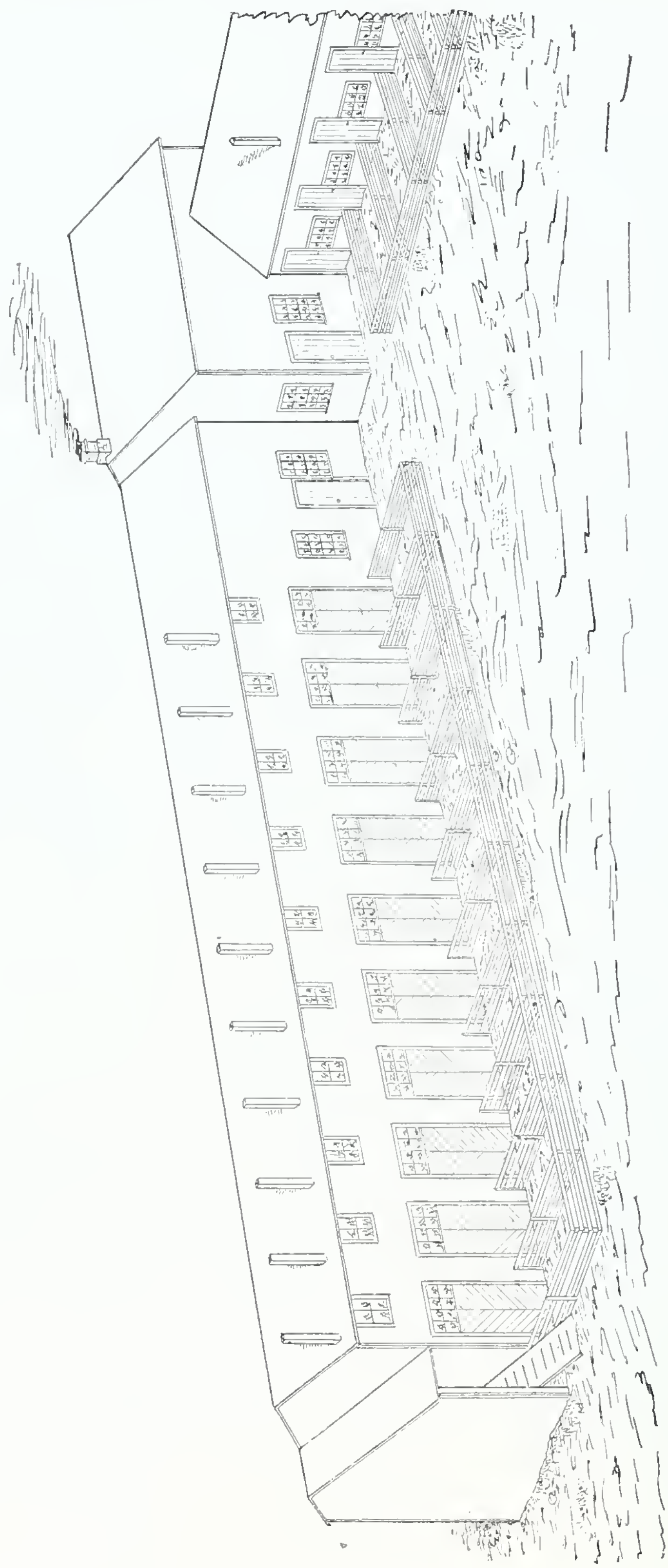

FIG. 28.—Showing Elevation of Sheep Barn.

THE STATION SHEEP BARN.

L. H. ADAMS.

The erection of a building for the accommodation of sheep at the Station farm was commenced in the fall of 1889; important additions having been made during the fall of 1891. It is believed that a description of the building now embodying as it does improvements suggested by a two years' experience with the part first erected will not be without interest to many.

The building consists of a main part 24x30 feet, two stories high, under the whole of which is a root cellar, and two wings reaching off at right angles from it. The east wing is 125 feet long, 18 feet wide and one story high.

The south wing, to which we will now confine our description, is 100 feet long, 18 feet wide and two stories high. An alley or passage way four feet wide is partitioned off along the entire west side of the building by means of a low fence like partition. (See Fig. 29.) This leaves a space 14 feet wide and a little over 83 feet in length, exclusive of a lambing room which will be described further on, that may be occupied by the flock as one large room, or it may be divided into any desired number of pens up to ten, by means of a light but strongly fashioned panel that rests in grooves made for it at each end. (See Fig. 30.) These panels are easily managed, and when placed in position, are entirely secure without fastenings of any kind.

Since it has been explained how all the space in the shed may be used as one room, we will from now on consider the building as it is when divided into ten parts. Each pen is 8 feet, 4 inches wide, and is entered from the passageway through a sliding gate (see Fig. 30), that is suspended from 2x4 scantling which is fastened in a horizontal position to the upright pieces of the passageway partition.

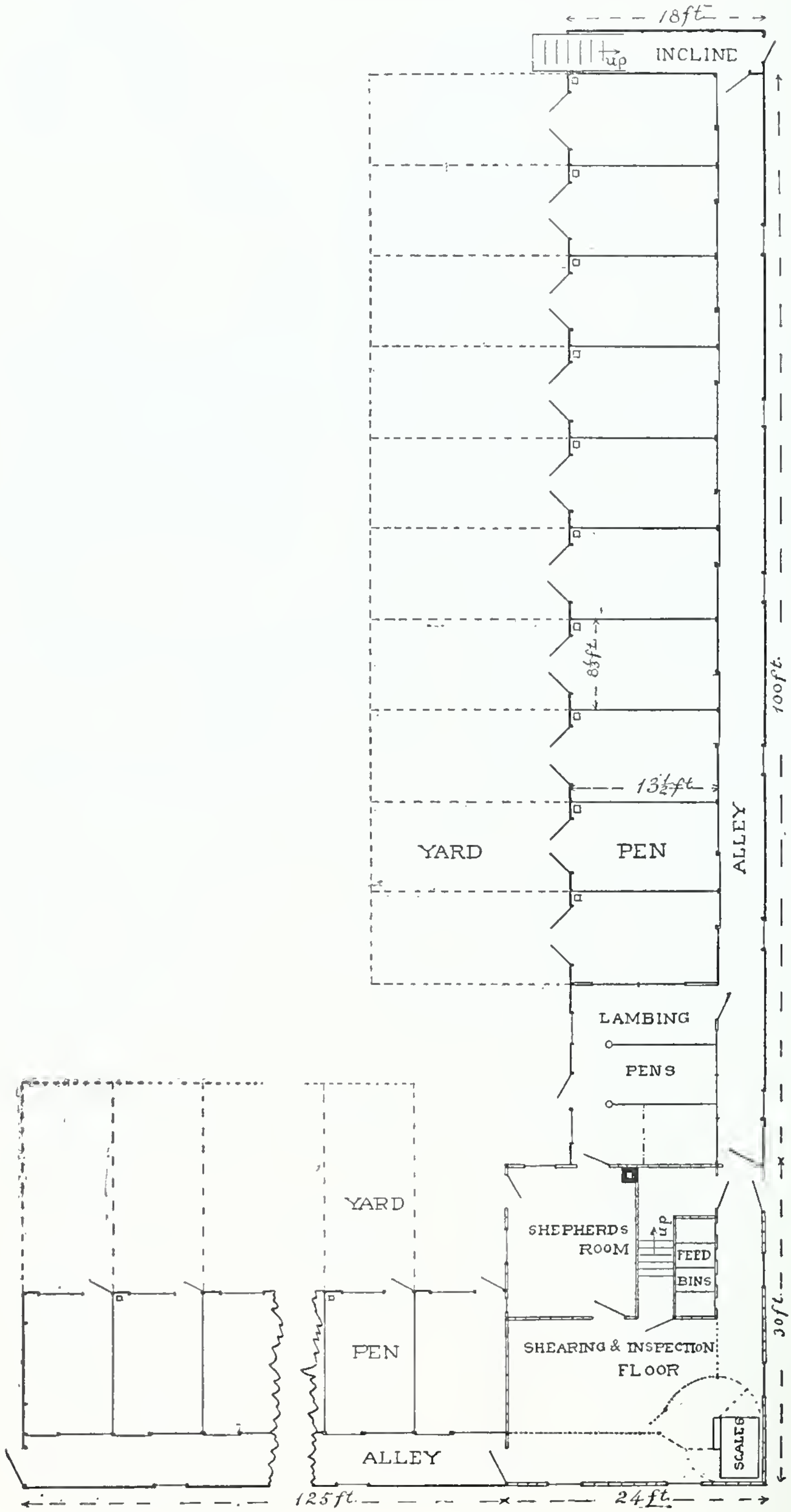

FIG. 29.—Showing Ground Plan of Sheep Barn.

Each pen is provided with a low flat bottomed trough for the feeding of grain and also a large hay or fodder rack (See Fig. 31). This hay rack is made with a light front which prevents chaff and dust from falling into the eyes and fleece of the sheep while feeding, and is also adjustable so that not only the angle of the front but the width of the opening at the bottom where the sheep draw the feed out may be changed to meet the necessities of the feed that is being used. The feeder or trough that is below the opening where the feed is drawn out serves an admirable purpose in catching all the finer parts of the hay or fodder that would otherwise be trampled under foot and wasted. This hay rack as illustrated in Figs. 32 and 33, is made to suit the conditions necessary for our experimental feeding, but it can be easily changed so as to meet the requirements of ordinary feeding by making it so that sheep can feed from both sides, and long enough to reach across the shed. It may serve the double purpose of feed rack and partition.

We now come to a point in the description of the building upon which I wish to place a good deal of emphasis, viz.: the arrangement of outside doors and windows. Experience has taught that adequate ventilation must be provided in all sheep buildings if trouble in their management would be avoided, and it appears that the building that is best adapted to the successful care of a flock is the one that may be the most readily and completely changed from an open to a closed shed according as the weather makes one or the other of the conditions essential. In recognition of these necessities referred to, each pen has double doors that when opened out into the yard make an opening that only lacks thirty-eight inches of being as wide as the pen. The manner in which these doors are operated and fastened may be seen in Fig. 30. One door is bolted securely at the top and bottom by bolts operated by a lever as shown in the figure, and the other one fastened to it by means of an ordinary thumb latch so that one or both doors may be opened at will. A slight upward movement of the lever allows both doors to swing open and when pushed shut a similar downward movement locks them safely.

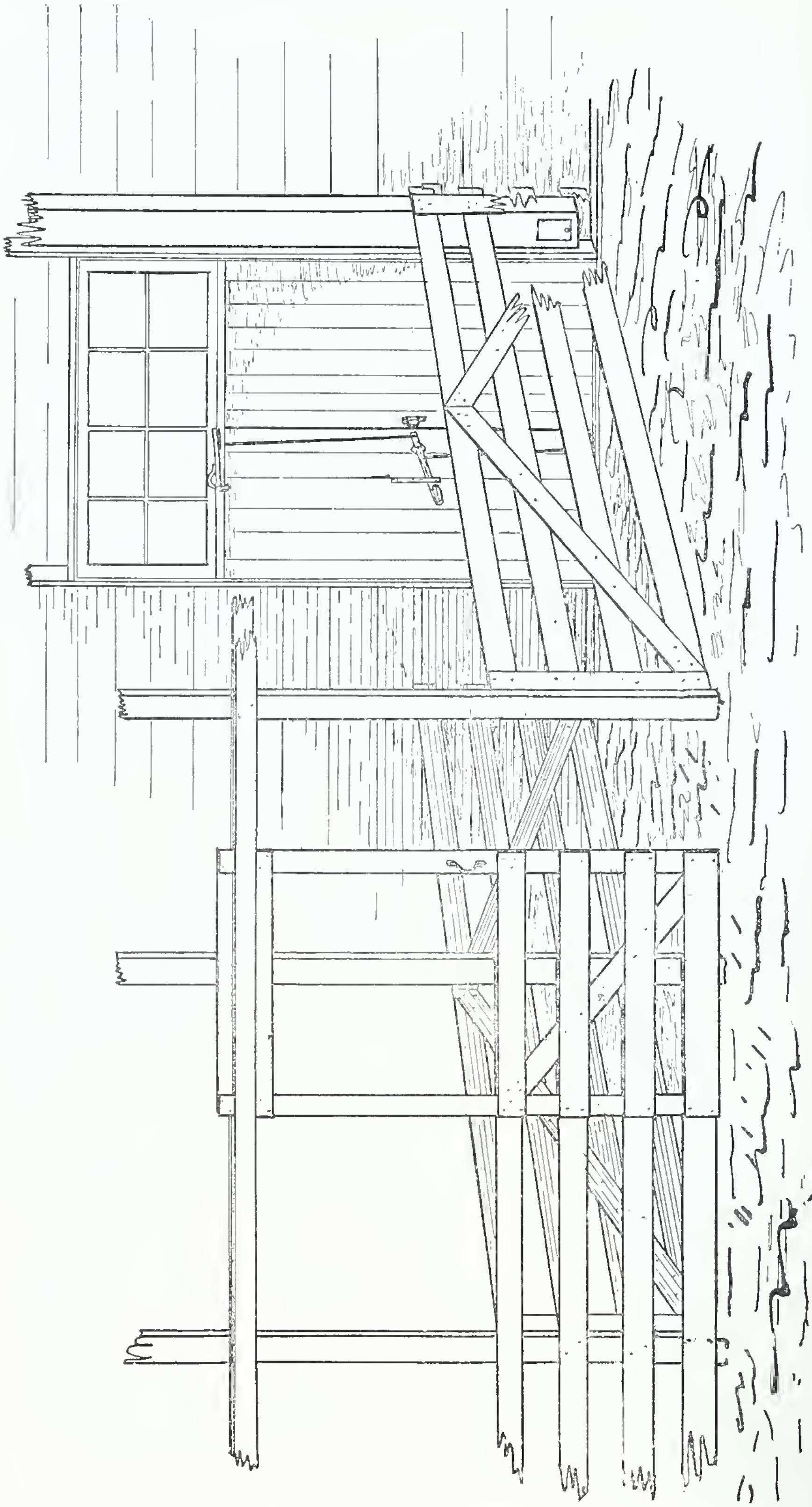

FIG. 30.—Interior of Sheep Barn, showing one of the divisions.

Over these double doors are windows that are the same width as the doors and two feet high. These windows are hinged at the top and are opened and closed from the passage way by means of a rope that runs over two small pulleys. The windows are provided with a fastening device, (See Fig. 34), that works automatically. A pull on the rope from the passageway unlocks the window and raises it up at the same time. When the rope is released the window closes and locks itself. Since the windows are operated from the alley way time is saved and annoyance and confusion to the sheep prevented.

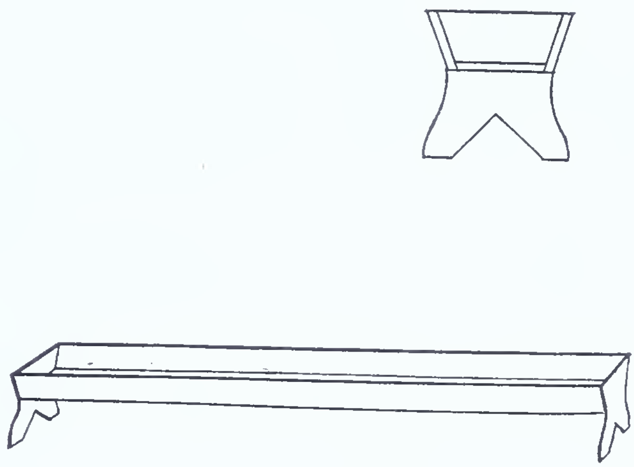

FIG. 31.—Feeding trough for sheep.

From what has been said it is easy to see how readily the barn may be converted into an open shed. If the weather is stormy but not cold, the flock can be kept in the barn with the closed doors and the large windows left wide open which will insure the admission of an abundance of fresh air without the bad results following the exposure to a draught directly upon their bodies. Should it become necessary to close the barn tight we still have ventilation by means of shafts that are constantly carrying off air from near the floor of each pen. These shafts (See Figs. 28 and 30) are simple wooden boxes that start a foot from the floor and extend up through the roof as high as the peak. They are made by nailing two 8 and two 10-inch boards together. Near the bottom on one side of the shaft is an opening for

the admission of air, the flow of which can be regulated by a door that is hinged at the bottom and pushes into the shaft.

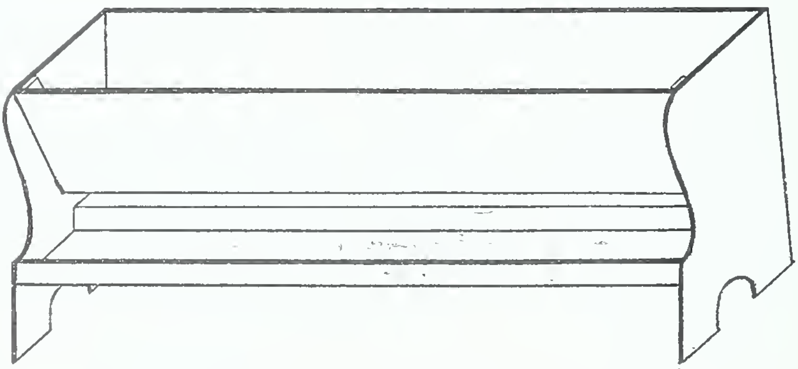

FIG. 32.—Hay rack in sheep barn.

A lambing room occupies the space of two pens in the partition adjoining the main barn. It is 14x16⅔ feet. This room is inclosed by tight walls on all four sides, with an outside door and a door leading to the shepherd's room. The wall next the alley way and that next the first pen are provided with wide hanging doors hinged above extending horizontally which reach from about two feet below the ceiling to a point four feet above the floor. In cold weather they are fastened down, at other times they are swung to the ceiling, leaving the pen light and airy. By means of movable partitions this will accommodate six or eight ewes at lambing time.

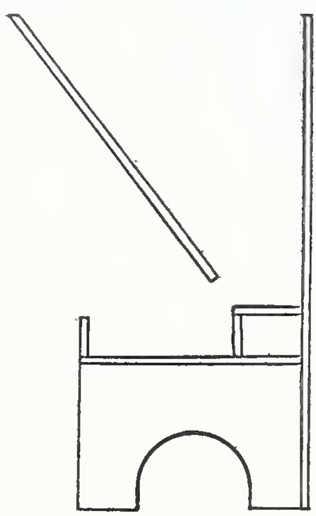

FIG. 33.—Hay rack in sheep barn, side view.

The second story of this barn is arranged for sheep also. The floor is constructed of one inch matched material with a coating of gas tar mopped on while hot. There are no permanent partitions of any kind upstairs. The space is divided by means of light fence panels to suit the ever changing conditions and requirements of our experimental work. The sheep in going to and from the second story pass up and down through a chute at the end of the barn. (See Fig. 28.)

Before passing to a description of the main part, I will add that the east or one story wing has a four foot passage way along the north side which leaves a room 14 feet wide by 125 feet in length. This may be occupied as one room or divided into any number of pens up to fifteen, which is the maximum. The gates and panels are similar to those described in the south wing.

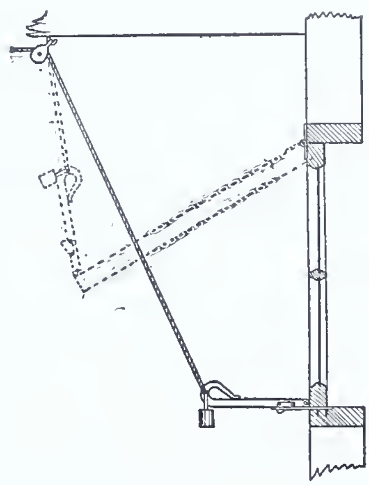

FIG. 34.—Fastening device for windows.

A reference to Fig. 29 will show that the main barn is arranged to be convenient for both wings. The scales are located in the corner where the passageways from the wings meet. By this plan the sheep may be let out from any pen in either wing and driven along the passageway to the scales. The shepherd's room is in the southwest corner and by means of small windows in the partition a view of the whole interior of both wings may be had. A door from this room opens directly into the lambing room

and if necessary the lambing room can be warmed by heat from the shepherd's room.

The dotted lines in Fig. 29, represent a railing three feet high that forms the passageway partition, and the space between this railing and the shepherd's room is used both as a shearing floor and an inspection room for the use of students while studying or judging animals. Feeding bins and stairways leading to the second story of the south wing and to the root cellar below occupy the balance of the space on this floor as shown in Fig. 29.

While this sheep barn has been arranged with reference to the experimental work of the Station, it is believed that some of its features are worthy of being used in the barns and sheds of our practical sheep farms.

CHEMICAL COMPOUNDS FOR PREVENTING THE GROWTH OF HORNS ON CATTLE.

L. H. ADAMS.

So far as the information of the Station goes, to Mr. John March, of Shullsburg, Wis., belongs the credit of preparing the first compound successfully used in preventing the growth of horns on young calves. The preparations sold by Mr. March and also that of Lewis and Bennett, of Bloomington, Wis., have been tried at the Station with satisfactory results. They were tried on a number of calves at different ages during the fall of 1889, with a view of obtaining definite knowledge as to the manner and proper age for application.

It was found in a majority of instances that the best results were reached when the compound was applied as soon as it was possible to locate the little horn button on the calf's head, which usually can be done when it is but three or four days old. From our experience it would seem that the dehorning compound should be fresh and the contents of the bottle well mixed before using; otherwise only partail success may be reached. The hair should be clipped from about the embryo horn with scissors, and the chemical applied with the rubber cork, wet with the fluid and rubbed hard over the button until it has penetrated the horn germ. When the germ has become soft, having an inflamed appearance, sufficient material has been applied. Care should be taken that no fluid run down the calf's head, for the material is very caustic.

In our tests, in several instances, the fluid was applied to but one horn button, the other being left untreated. The effect usually was to entirely stop the growth of one horn,

while the other grew naturally. The calves were sold to a farmer not far distant, who agreed to keep them until grown that we might see the effect of the treatment. Fig. 35 was redrawn from a photograph of a grade Jersey heifer

FIG. 35.—Head of 2 year old grade Jersey he fer, showing effect of using chemical dehorner in preventing the growth of the left horn.

at two years of age, showing that the left horn, to which the compound was applied, never developed. Fig. 36 shows the right horn (with the shell removed) naturally developed, while the left side of the head to which the chemical was applied has not only failed to develop the horn, but even the heavy base which grows out from the skull to support it. This failure to develop not only the horn but its natural support, raises the query of whether a hornless race of cattle could not be developed by using the dehorning compound for a number of generations.

In advertisements of chemical fluids it is often claimed that the application is painless, but our observations do not coincide with any such statement. The application of a

fluid powerful enough to destroy so large a surface as the button on the calf's head must produce a great deal of pain, and the calves show this by nervous movements of the head and attempting to rub the irritated spot. From our experience in applying the liquid and also in cutting out the horns with instruments, we believe that when used the fluid should be applied to as young calves as possible, since the older the calf grows the more it seems to suffer when the horns are removed.

FIG. 36.—Skull of another grade Jersey heifer, showing how by the application of chemicals, the horn and the base of the skull which supports it, have failed to develop.

THE ESTIMATION OF THE TOTAL SOLIDS IN MILK FROM THE PER CENT. OF FAT AND THE SPECIFIC GRAVITY OF THE MILK.

S. M. BABCOCK.

The relation between the composition and specific gravity of milk has received considerable attention in recent times, and several formulæ have been proposed as aids in determining the composition of milk when its specific gravity and either the per cent. of total solids or fat are known. The introduction of simple and accurate methods for the estimation of fat gives such formulæ a special interest as by making a direct determination of fat by some of the rapid methods and using the result in a formula for the estimation of total solids an approximately accurate judgment concerning the composition of any milk may be obtained without the use of a chemical balance and in a much shorter time than would be required for obtaining the total solids alone. Moreover by basing the use of formulæ upon a determination of the fat instead of upon the total solids the errors arising from inaccurate determinations of the specific gravity fall upon the least valuable constituents of the milk, viz: the solids not fat, so that the chief objections that have been raised to the use of these formulæ no longer exist.

The formula most generally adopted for calculations of this kind is the one prepared by Fleischmann,* which is as follows:

$$t = 1.2\ f + 2.665\ \frac{100\ S\ -\ 100}{S}$$

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* Journal für Landwirthschaft, 1883 — pp. 251–269.

in which t = per cent. of total solids; f = per cent. of fat in milk and S = Specific gravity of milk at 15° C. The formula which I have used in calculating the accompanying table is

$$\text{Solids not fat} = \left(\frac{100\ S\ -\ Sf}{100\ -\ 1.0753\ Sf} - 1\right)\ x\ (100 - f)\ 2.6$$

in which S = Specific gravity of milk at 60° F. and f = per cent of fat.

The table gives per cents. of solids not fat corresponding to Quevenne lactometer readings (1000 sp. gr. — 1000) from 17 to 40 and for each tenth per cent. of fat up to 6 per cent.

To use the table find in the first vertical column the number corresponding to the Quevenne lactometer reading of the milk and follow along the horizontal line in which this appears to the column headed with the per cent. of fat in the milk; the number common to both of these lines is the per cent. of solids not fat in the milk. To find the total solids add the per cent. of solids not fat, as found in the table, to the per cent. of fat.

Table showing per cent. of solids not fat corresponding to per cent. of fat and Quevenne laetometer reading.

Lactometer reading.	Per Cent. of Fat. .0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	Lactometer reading.
17	4.42	4.44	4.46	4.48	4.50	4.52	4.54	4.56	4.58	4.60	4.62	4.64	4.66	4.68	4.70	4.73	4.75	4.77	4.79	4.81	4.83	 17
18	4.68	4.70	4.72	4.74	4.76	4.78	4.80	4.82	4.84	4.86	4.88	4.90	4.92	4.95	4.97	4.99	5.01	5.03	5.05	5.07	5.09	 18
19	4.94	4.96	4.98	5.00	5.02	5.04	5.06	5.08	5.10	5.12	5.14	5.17	5.19	5.21	5.23	5.25	5.27	5.29	5.31	5.33	5.35	 19
20	5.20	5.22	5.24	5.26	5.28	5.30	5.32	5.34	5.36	5.38	5.40	5.43	5.45	5.47	5.49	5.51	5.53	5.55	5.57	5.59	5.61	 20
21	5.46	5.48	5.50	5.52	5.54	5.56	5.58	5.60	5.62	5.64	5.66	5.69	5.71	5.73	5.75	5.77	5.79	5.81	5.83	5.85	5.87	 21
22	5.72	5.74	5.76	5.78	5.80	5.82	5.84	5.86	5.88	5.90	5.93	5.95	5.97	5.99	6.01	6.03	6.05	6.07	6.09	6.11	6.13	 22
23	5.98	6.00	6.02	6.04	6.06	6.08	6.10	6.12	6.14	6.17	6.19	6.21	6.23	6.25	6.27	6.29	6.31	6.33	6.35	6.37	6.39	 23
24	6.24	6.26	6.28	6.30	6.32	6.34	6.36	6.38	6.40	6.43	6.45	6.47	6.49	6.51	6.53	6.55	6.57	6.59	6.61	6.63	6.65	 24
25	6.50	6.52	6.54	6.56	6.58	6.60	6.62	6.64	6.67	6.69	6.71	6.73	6.75	6.77	6.79	6.81	6.83	6.85	6.87	6.90	6.92	 25
26	6.76	6.78	6.80	6.82	6.84	6.86	6.88	6.91	6.93	6.95	6.97	6.99	7.01	7.03	7.05	7.07	7.09	7.11	7.14	7.16	7.18	 26
27	7.02	7.04	7.06	7.08	7.10	7.12	7.14	7.17	7.19	7.21	7.23	7.25	7.27	7.29	7.31	7.33	7.35	7.38	7.40	7.42	7.44	 27
28	7.28	7.30	7.32	7.34	7.36	7.38	7.40	7.43	7.45	7.47	7.49	7.51	7.53	7.55	7.57	7.59	7.61	7.64	7.66	7.68	7.70	 28
29	7.54	7.56	7.58	7.60	7.62	7.64	7.66	7.69	7.71	7.73	7.75	7.77	7.79	7.81	7.83	7.85	7.88	7.90	7.92	7.94	7.96	 29
30	7.80	7.82	7.84	7.86	7.88	7.90	7.93	7.95	7.97	7.99	8.01	8.03	8.05	8.07	8.09	8.12	8.14	8.16	8.18	8.20	8.22	 30
31	8.06	8.08	8.10	8.12	8.14	8.16	8.19	8.21	8.23	8.25	8.27	8.29	8.31	8.33	8.36	8.38	8.40	8.42	8.44	8.46	8.48	 31
32	8.32	8.34	8.36	8.38	8.40	8.42	8.45	8.47	8.49	8.51	8.53	8.55	8.57	8.59	8.62	8.64	8.66	8.68	8.70	8.72	8.74	 32
33	8.58	8.60	8.62	8.64	8.66	8.68	8.71	8.73	8.75	8.77	8.79	8.81	8.83	8.85	8.88	8.90	8.92	8.94	8.96	8.98	9.01	 33
34	8.84	8.86	8.88	8.90	8.92	8.95	8.97	8.99	9.01	9.03	9.05	9.07	9.09	9.12	9.14	9.16	9.18	9.20	9.22	9.24	9.27	 34
35	9.10	9.12	9.14	9.16	9.18	9.21	9.23	9.25	9.27	9.29	9.31	9.33	9.35	9.38	9.40	9.42	9.44	9.46	9.48	9.51	9.53	 35
36	9.36	9.38	9.40	9.42	9.44	9.47	9.49	9.51	9.53	9.55	9.57	9.59	9.62	9.64	9.66	9.68	9.70	9.72	9.75	9.77	9.79	 36
37	9.62	9.64	9.66	9.68	9.70	9.73	9.75	9.77	9.79	9.81	9.83	9.85	9.88	9.90	9.92	9.94	9.96	9.98	10.01	10.03	10.05	 37
38	9.88	9.90	9.92	9.94	9.97	9.99	10.01	10.03	10.05	10.07	10.09	10.12	10.14	10.16	10.18	10.20	10.22	10.25	10.27	10.29	10.31	 38
39	10.14	10.16	10.18	10.20	10.23	10.25	10.27	10.29	10.31	10.33	10.35	10.38	10.40	10.42	10.44	10.46	10.48	10.51	10.53	10.55	10.57	 39
40	10.40	10.42	10.44	10.46	10.49	10.51	10.53	10.55	10.57	10.59	10.61	10.64	10.66	10.68	10.70	10.72	10.75	10.77	10.79	10.81	10.83	 40

Table for solids not fat.—Continued.

Lactometer reading.	PER CENT. OF FAT.																					Lactometer reading.
	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	
17	4.83	4.85	4.87	4.89	4.91	4.93	4.95	4.97	4.99	5.01	5.03	5.05	5.07	5.09	5.11	5.14	5.16	5.18	5.20	5.22	5.24	 17
18	5.09	5.11	5.13	5.15	5.17	5.19	5.21	5.23	5.25	5.27	5.29	5.31	5.33	5.36	5.38	5.40	5.42	5.44	5.46	5.48	5.50	 18
19	5.35	5.37	5.39	5.41	5.43	5.45	5.47	5.49	5.51	5.54	5.56	5.58	5.60	5.62	5.64	5.66	5.68	5.70	5.72	5.74	5.76	 19
20	5.61	5.63	5.65	5.67	5.69	5.71	5.73	5.76	5.78	5.80	5.82	5.84	5.86	5.88	5.90	5.92	5.94	5.96	5.98	6.00	6.02	 20
21	5.87	5.89	5.91	5.93	5.95	5.98	6.00	6.02	6.04	6.06	6.08	6.10	6.12	6.14	6.16	6.18	6.20	6.22	6.24	6.27	6.29	 21
22	6.13	6.15	6.17	6.19	6.22	6.24	6.26	6.28	6.30	6.32	6.34	6.36	6.38	6.40	6.42	6.44	6.46	6.49	6.51	6.53	6.55	 22
23	6.39	6.41	6.44	6.46	6.48	6.50	6.52	6.54	6.56	6.58	6.60	6.62	6.64	6.66	6.69	6.71	6.73	6.75	6.77	6.79	6.81	 23
24	6.65	6.68	6.70	6.72	6.74	6.76	6.78	6.80	6.82	6.84	6.86	6.88	6.90	6.93	6.95	6.97	6.99	7.01	7.03	7.05	7.07	 24
25	6.92	6.94	6.96	6.98	7.00	7.02	7.04	7.06	7.08	7.10	7.13	7.15	7.17	7.19	7.21	7.23	7.25	7.27	7.29	7.31	7.34	 25
26	7.18	7.20	7.22	7.24	7.26	7.28	7.30	7.32	7.35	7.37	7.39	7.41	7.43	7.45	7.47	7.49	7.51	7.53	7.56	7.58	7.60	 26
27	7.44	7.46	7.48	7.50	7.52	7.54	7.56	7.59	7.61	7.63	7.65	7.67	7.69	7.71	7.73	7.75	7.78	7.80	7.82	7.84	7.86	 27
28	7.70	7.72	7.74	7.76	7.78	7.81	7.83	7.85	7.87	7.89	7.91	7.93	7.95	7.97	8.00	8.02	8.04	8.06	8.08	8.10	8.12	 28
29	7.96	7.98	8.00	8.02	8.05	8.07	8.09	8.11	8.13	8.15	8.17	8.19	8.21	8.24	8.26	8.28	8.30	8.32	8.34	8.36	8.38	 29
30	8.22	8.24	8.26	8.29	8.31	8.33	8.35	8.37	8.39	8.41	8.43	8.46	8.48	8.50	8.52	8.54	8.56	8.58	8.60	8.63	8.65	 30
31	8.48	8.50	8.53	8.55	8.57	8.59	8.61	8.63	8.65	8.67	8.70	8.72	8.74	8.76	8.78	8.80	8.82	8.84	8.87	8.89	8.91	 31
32	8.74	8.77	8.79	8.81	8.83	8.85	8.87	8.89	8.92	8.94	8.96	8.98	9.00	9.02	9.04	9.06	9.09	9.11	9.13	9.15	9.17	 32
33	9.01	9.03	9.05	9.07	9.09	9.11	9.13	9.16	9.18	9.20	9.22	9.24	9.26	9.28	9.30	9.33	9.35	9.37	9.39	9.41	9.43	 33
34	9.27	9.29	9.31	9.33	9.35	9.37	9.39	9.42	9.44	9.46	9.48	9.50	9.52	9.55	9.57	9.59	9.61	9.63	9.65	9.67	9.70	 34
35	9.53	9.55	9.57	9.59	9.61	9.63	9.66	9.68	9.70	9.72	9.74	9.76	9.79	9.81	9.83	9.85	9.87	9.89	9.91	9.94	9.96	 35
36	9.79	9.81	9.83	9.85	9.87	9.90	9.92	9.94	9.96	9.98	10.00	10.03	10.05	10.07	10.09	10.11	10.13	10.16	10.18	10.20	10.22	 36
37	10.05	10.07	10.09	10.11	10.14	10.16	10.18	10.20	10.22	10.24	10.27	10.29	10.31	10.33	10.35	10.37	10.40	10.42	10.44	10.46	10.48	 37
38	10.31	10.33	10.35	10.38	10.40	10.42	10.44	10.46	10.48	10.51	10.53	10.55	10.57	10.59	10.61	10.64	10.66	10.68	10.70	10.72	10.75	 38
39	10.57	10.59	10.62	10.64	10.66	10.68	10.70	10.72	10.75	10.77	10.79	10.81	10.83	10.85	10.88	10.90	10.92	10.94	10.96	10.99	11.01	 39
40	10.83	10.86	10.88	10.90	10.92	10.94	10.96	10.99	11.01	11.03	11.05	11.07	11.09	11.12	11.14	11.16	11.18	11.20	11.23	11.25	11.27	 40

Table for solids not fat—Continued.

Lactometer reading.	Per Cent. of Fat.																					Lactometer reading.
	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	
17	5.24	5.26	5.28	5.30	5.32	5.34	5.36	5.38	5.40	5.42	5.44	5.46	5.48	5.51	5.53	5.55	5.57	5.59	5.61	5.63	5.65	 17
18	5.50	5.52	5.54	5.56	5.58	5.60	5.62	5.64	5.66	5.69	5.71	5.73	5.75	5.77	5.79	5.81	5.83	5.85	5.87	5.89	5.91	 18
19	5.76	5.78	5.80	5.82	5.84	5.86	5.89	5.91	5.93	5.95	5.97	5.99	6.01	6.03	6.05	6.07	6.09	6.11	6.13	6.16	6.18	 19
20	6.02	6.04	6.07	6.09	6.11	6.13	6.15	6.17	6.19	6.21	6.23	6.25	6.27	6.29	6.31	6.34	6.36	6.38	6.40	6.42	6.44	 20
21	6.29	6.31	6.33	6.35	6.37	6.39	6.41	6.43	6.45	6.47	6.49	6.52	6.54	6.56	6.58	6.60	6.62	6.64	6.66	6.68	6.70	 21
22	6.55	6.57	6.59	6.61	6.63	6.65	6.67	6.69	6.72	6.74	6.76	6.78	6.80	6.82	6.84	6.86	6.88	6.90	6.92	6.95	6.97	 22
23	6.81	6.83	6.85	6.87	6.89	6.92	6.94	6.96	6.98	7.00	7.02	7.04	7.06	7.08	7.10	7.13	7.15	7.17	7.19	7.21	7.23	 23
24	7.07	7.09	7.12	7.14	7.16	7.18	7.20	7.22	7.24	7.26	7.28	7.30	7.33	7.35	7.37	7.39	7.41	7.43	7.45	7.47	7.49	 24
25	7.34	7.36	7.38	7.40	7.42	7.44	7.46	7.48	7.50	7.53	7.55	7.57	7.59	7.61	7.63	7.65	7.67	7.69	7.72	7.74	7.76	 25
26	7.60	7.62	7.64	7.66	7.68	7.70	7.73	7.75	7.77	7.79	7.81	7.83	7.85	7.87	7.89	7.92	7.94	7.96	7.98	8.00	8.02	 26
27	7.86	7.88	7.90	7.92	7.94	7.97	7.99	8.01	8.03	8.05	8.07	8.09	8.11	8.14	8.16	8.18	8.20	8.22	8.24	8.26	8.28	 27
28	8.12	8.14	8.16	8.19	8.21	8.23	8.25	8.27	8.29	8.31	8.33	8.36	8.38	8.40	8.42	8.44	8.46	8.48	8.50	8.53	8.55	 28
29	8.38	8.41	8.43	8.45	8.47	8.49	8.51	8.53	8.55	8.58	8.60	8.62	8.64	8.66	8.68	8.70	8.73	8.75	8.77	8.79	8.81	 29
30	8.65	8.67	8.69	8.71	8.73	8.75	8.77	8.80	8.82	8.84	8.86	8.88	8.90	8.92	8.95	8.97	8.99	9.01	9.03	9.05	9.07	 30
31	8.91	8.93	8.95	8.97	8.99	9.02	9.04	9.06	9.08	9.10	9.12	9.15	9.17	9.19	9.21	9.23	9.25	9.27	9.30	9.32	9.34	 31
32	9.17	9.19	9.21	9.24	9.26	9.28	9.30	9.32	9.34	9.37	9.39	9.41	9.43	9.45	9.47	9.49	9.52	9.54	9.56	9.58	9.60	 32
33	9.43	9.46	9.48	9.50	9.52	9.54	9.56	9.58	9.61	9.63	9.65	9.67	9.69	9.71	9.74	9.76	9.78	9.80	9.82	9.84	9.87	 33
34	.70	9.72	9.74	9.76	9.78	9.80	9.83	9.85	9.87	9.89	9.91	9.93	9.96	9.98	10.00	10.02	10.04	10.06	10.09	10.11	10.13	 34
35	9.96	9.98	10.00	10.02	10.04	10.07	10.09	10.11	10.13	10.15	10.17	10.20	10.22	10.24	10.26	10.28	10.31	10.33	10.35	10.37	10.39	 35
36	10.22	10.24	10.26	10.29	10.31	10.33	10.35	10.37	10.39	10.42	10.44	10.46	10.48	10.50	10.52	10.55	10.57	10.59	10.61	10.63	10.66	 36
37	10.48	10.50	10.53	10.55	10.57	10.59	10.61	10.64	10.66	10.68	10.70	10.72	10.74	10.77	10.79	10.81	10.83	10.85	10.88	10.90	10.92	 37
38	10.75	10.77	10.79	10.81	10.83	10.85	10.88	10.90	10.92	10.94	10.96	10.99	11.01	11.03	11.05	11.07	11.10	11.12	11.14	11.16	11.18	 38
39	11.01	11.03	11.05	11.07	11.09	11.12	11.14	11.16	11.18	11.20	11.23	11.25	11.27	11.29	11.31	11.34	11.36	11.38	11.40	11.42	11.45	 39
40	11.27	11.29	11.31	11.34	11.36	11.38	11.40	11.42	11.45	11.47	11.49	11.51	11.53	11.55	11.58	11.60	11.62	11.64	11.67	11.69	11.71	 40

A SIMPLE FORMULA.

Among the numerous formulæ that have been proposed for the calculation of the solids of milk from the specific gravity and per cent. of fat, not one, that is sufficiently accurate for general use, is easily applied without tables and I believe the limited use of such formulæ in this country may be attributed to this fact. This objection does not hold with the formula given below as it is simple enough to be easily remembered and can be quickly applied without tables. At the same time the results obtained by it are, with normal milks containing not more than 6 per cent. fat, nearly as accurate as are those by any other formula. For this reason I believe it to be well adapted to the wants of dairymen and others who may wish to know more about the composition of milk than is expressed by the amount of fat. This formula has been used the past two winters by students in the Dairy School at the University of Wisconsin and by it they have been enabled, in most cases, to detect the common adulterations of milk, such as the abstraction of fat or the addition of water.

This formula is as follows:

$$\text{Solids not fat} = \frac{L + .7\,f}{3.8} \quad \text{and}$$

$$\text{Total solids} = \frac{L + .7\,f}{3.8} + f$$

in which L = Reading of Quevenne lactometer at 60° F. and f = per cent. of fat.

This formula agrees with the more general formula, by which the table is calculated, when applied to milks containing between 3 and 4 per cent of fat. For milks containing less than 3 per cent of fat the formula gives results a trifle too high, and for milks above 4 per cent of fat a trifle too low, the error, however, will not amount to as much as .1 per cent with any normal milk containing less than 6 per cent of fat. If more accurate results are desired the solids not fat as found by this formula may be corrected as follows:

For milks containing less than 1 pct. of fat subtract..........	.09
For milks containing from 1 to 2 pct. of fat subtract..........	.06
For milks containing from 2 to 3 pct. of fat subtract..........	.03
For milks containing from 3 to 4 pct. of fat subtract....	.00
For milks containing from 4 to 5 pct. of fat add..............	.03
For milks containing from 5 to 6 pct. of fat add......	.06

and so on adding .03 to the solids not fat, as shown by the formula, for each per cent. of fat above 4 which the milk contains. Corrected in this way the results will agree closely with those obtained by the general formula, for milks or creams containing not more than 20 per cent. of fat.

For ordinary purposes no correction need be applied as the errors of observation, in obtaining the necessary data, would generally be greater than those arising from defects in the formula.

This formula expressed in words gives the following rule for the calculation of solids not fat and of total solids, when the Quevenne lactometer reading and per cent. of fat are known:

Add the Quevenne lactometer reading at 60° F. to seven-tenths of the per cent. of fat and divide the sum by 3.8. The result will be the solids not fat, and this added to the per cent. of fat gives the per cent. of total solids.

The relations which exist in normal milks, between the factors which enter into the last formula are such that the accuracy of the formula is but slightly affected by changing to the following:

$$\text{Solids not fat} = \frac{L + f}{4}$$

This simple expression gives results with average herd milks which do not vary more than .1 from those obtained by the general formula given above and is consequently well adapted for use in factories in making preliminary examinations for adulterations.

THE DETERMINATION OF THE SPECIFIC GRAVITY.

The chief source of error in the use of such formulæ as are described in this report, lies in the determination of the

specific gravity and consequently this should be carefully taken. The following precautions are essential: Milk just after it is drawn is saturated with air which should be allowed to escape before the specific gravity is determined, otherwise the result will be too low. To be on the safe side, milk should stand at least one hour after being milked before the test is made. The temperature of the milk should be brought by warming or cooling to 60° F., and then thoroughly mixed by pouring from one vessel to another with care to avoid as much as possible the introduction of small bubbles of air. The specific gravity may then be accurately determined with a picnometer or a Westphal balance, but for general purposes a good hydrometer or lactometer is sufficiently accurate, and on account of its convenience is to be preferred.

THE LACTOMETER.

There are several kinds of lactometers in use at the present time, all of which have the same general form, viz.: a narrow stem to which is attached an elongated bulb weighted at the bottom so as to float in an upright position in milk, with the stem partially submerged. The depth to which the lactometer sinks depends upon the specific gravity of the liquid in which it is placed, a heavy liquid causing the stem to rise higher above the surface than a light liquid. It shows, the relative weights of equal volumes of milk tested.

The lactometer most generally used in this country is graduated from 0 to 120 degrees, 0 being the point on the stem to which the instrument sinks in pure water at 60° F. and 100 the point to which it sinks in a liquid having a specific gravity of 1.029, this being assumed to be the lowest specific gravity compatible with pure milk. The intermediate readings are intended to show the per cent. of milk, having a specific gravity of 1.029, which the sample examined contains. This, however, it does not do, for when milk is skimmed it will give a higher reading upon the lactometer than it did before the cream was removed and the addition of cream to milk affects the reading in the

same way as the addition of water. Although an experienced person would rarely if ever be deceived by these readings, owing to the changed appearance of milk that has been skimmed or watered, factorymen and others are often misled by them. For this reason, and also because it is necessary when the readings are to be used, in connection with the per cent. of fat, for the calculation of total solids, to know the specific gravity of the milk, the Quevenne lactometer is to be preferred. The scale of this lactometer expresses in thousandths the difference between the specific gravity of the liquid tested and water, the specific gravity of water being 1. In other words the reading of this lactometer is equal to the specific gravity of the milk in which it is placed, less 1 multiplied by 1,000. To illustrate, milk having a specific gravity of 1.0325 would give with this lactometer a reading of 32.5 and, on the other hand a reading of 33 on this lactometer, corresponds to a specific gravity of 1.033. It is therefore easy to convert lactometer degrees into specific gravity and specific gravity into lactometer degrees. These lactometers are usually graduated from 15 to 40 degrees; if the scale were extended to 0, this would be found at that point on the stem to which the instrument sinks in pure water at a temperature of 60° F. The 0 points of both of the lactometers mentioned correspond. The scale of the ordinary lactometer may be converted into the Quevenne scale by multiplying by .29. For convenience a table is given showing the relation between the two scales. The Quevenne readings are given to the nearest tenth.

Table showing the Quevenne lactometer degrees corresponding to the scale of the ordinary lactometers that are graduated from 0 *to* 120.

Ordinary Scale.	Quevenne Scale.	Ordinary Scale.	Quevenne Scale.
60	17.4	91	26.3
61	17.7	92	26 7
62	18.	93	27.
63	18.3	94	27.3
64	18.6	95	27.6
65	18.8	96	27.8
66	19.1	97	28.1
67	19.4	98	28.4
68	19.7	99	28.7
69	20.	100	29.
70	29.3	101	29.3
71	20.6	102	29.6
72	20.9	103	29.9
73	21.2	104	30.2
74	21.5	105	30.5
75	21.7	106	30.7
76	22.	107	31.
77	22.3	108	31.3
78	22.6	109	31.6
79	22.9	110	31.9
80	23.2	111	32.2
81	23.5	112	32.5
82	23.8	113	32.8
83	24.1	114	33.1
84	24.4	115	33.4
85	24.6	116	33.6
86	24.9	117	33.9
87	25.2	118	34.2
88	25.5	119	34.5
89	25.8	120	34.8
90	26.1		

The sensitiveness of a lactometer depends upon the relation between the volume of the bulb and the diameter of the stem, a large bulb and small stem being most sensitive.

A bulb $1\frac{1}{8}$ inch in diameter and 3 inches long with a stem about $\frac{1}{4}$ inch in diameter gives suitable proportions for a dairy lactometer. It is advisable to have the instrument combined with a thermometer, and when this is done it is more convenient to have the thermometer scale placed above the lactometer scale so that both scales can be read without removing the lactometer from the milk.

CORRECTIONS FOR TEMPERATURE.

Although it is always advisable to have the temperature of the milk carefully adjusted to 60° F., when the lactometer reading is taken, corrections for the Quevenne lactometer may be made, for slight deviations (not more than 10°) from the standard temperature, without serious error, by adding to the lactometer reading 0.1 for each degree that the temperature exceeds 60, and subtracting 0.1 for each degree below 60. For example, the lactometer reading is 33.5 and the temperature of the milk is 67° F. The corrected reading for 60° would be $33.5 + .7 = 34.2$. Had the temperature been 56° F., the corrected reading would be $33.5 - .4 = 33.1$.

DERIVATION OF THE FORMULA.

The formula used in calculating the table for solids not fat, on pages 294-296 of this Report, is derived as follows:

It is assumed that milk is a mechanical mixture of two constituents, viz.: milk serum, which is an aqueous solution of all of the solids of the milk except fat, and butter fat, which is suspended in very small particles in the milk serum, forming an emulsion with it. Such being the case the specific gravity of the milk will depend upon the specific gravity and relative amount of each of these constituents which the milk contains. The specific gravity of butter fat is practically the same in all milks, the variation being so slight that it does not materially affect results in investigations of this kind; on the other hand the specific gravity of milk serum is not constant, but depends upon the amount of solids which it contains in solution. Its specific gravity can never fall below 1. the specific

gravity of water, and rarely exceeds 1.040; in normal milks it usually falls between 1.030 and 1.040. The difference between the specific gravity of water and that of milk serum is nearly in direct proportion to the solids which the serum contains; if, therefore, this difference be divided by a constant factor which represents the increase in specific gravity caused by one per cent. of serum solids the result will be the per cent. of solids in the serum. If the per cent. of solids in the serum, found in this way, be multiplied by the per cent. of serum in the milk considered and the product divided by 100, the result will be the per cent. of solids not fat in this milk.

For convenience I shall represent the necessary factors in the following manner:

f = Per cent. of fat in any milk.
$100 - f$ = Per cent. of serum in any milk.
S = Specific gravity of milk at 60° F.
$.930$ = Specific gravity of butter fat at 60° F.
x = Specific gravity of the serum at 60° F.
a = Increase in the specific gravity of the serum caused by one per cent. of serum solids.

Then in accordance with what has been said above,

I. Per cent. of solids not fat in any milk $= \frac{x - 1}{a} \times \frac{100 - f}{100}$

It remains to find the value of x in terms of S and f and to determine from a large number of analyses the numerical value of the constant a.

The volume of a substance in cubic centimeters is equal to its weight in grams divided by its specific gravity; therefore

$$\frac{100}{S} = \text{Volume in c. c. of 100 grams of milk.}$$

$$\frac{100 - f}{x} = \text{Volume in c. c. of serum in 100 grams of milk.}$$

$$\frac{f}{.93} = 1.0753\,f. = \text{Volume in c. c. of fat in 100 grams of milk.}$$

and as the volume of the milk is equal to the sum of the volumes of the fat and serum

$$\frac{100}{S} = \frac{100 - f}{x} + 1.0753\ f$$

Clearing of fractions and reducing gives:

$$\text{II.} \quad x = \frac{100\ S - S\ f}{100 - 1.0753\ S\ f}$$

The constant (a) is determined from the average of a large number of analyses of milk by first finding the value of x in equation II subtracting 1. from this and dividing the remainder by the per cent. of solids which the serum contains. The per cent. of solids in the serum is found by dividing the per cent. of solids not fat in the milk by the per cent. of serum (100-f) and multiplying the quotient by 100.

The following table gives the data from which the value of (a) has been determined:

Average analyses of milk.

	No. of analyses.	Sp. Gr.	Total Solids per cent.	Fat per cent.	Sp. Gr. Serum (x)	Per cent. Solids in serum.	(a)
Jersey cow Jem....	153	1.0312	15.885	6.34	1.03885	10.190	.003812
Jersey cow Meg.	117	1.0326	14.365	4.925	1.03854	9.929	.003882
Herd milk (Jersey).......	94	1.0315	14.470	5.090	1.03758	9.883	.003802
Analyses from which Fleischmann's formula was derived.....	104	1.0312	11.953	3.242	1.03498	9.003	.003885

The first three series of analyses were made at the Agricultural Experiment Station, at Geneva, N. Y., in the years 1882-3. The last series is the average of 104 analyses upon which Fleishmann's formula is based. The milks included in the above averages ranged from under 3 per cent. to over 8 per cent. and the value of a derived from them is believed to be approximately correct. Giving each series of analyses the same weight and taking the average of values found gives

$$a = .003845.$$

and substituting the valne of x aud a in equation I and reducing gives:

$$\text{III. Solids not fat} = \left(\frac{100\ S - Sf}{100 - 1.0753\ Sf} - 1\right) \times (100 - f) \times 2.6$$

The more simple expression,

$$\text{Solids not fat} = \frac{L + .7f}{3.8}$$

is derived in the following manner: It is assumed as in the derivation of the preceding formula, that milk is a mechanical mixture of milk serum and fat, that the Quevenne lactometer reading, corresponding to the specific gravity of the milk serum, varies directly as the amount of solids in the serum, and that the lactometer reading for any milk depends upon the relative amounts of serum and fat which it contains. The factors common to the two formulae are designated in the manner already described; the additional factors are as follows:

L = Quevenne lactometer reading for any milk at 60° F.

y = Quevenne lactometer reading for serum of any milk at 60° F.

f′ = Volume per cent of fat in any milk.

a′ = a constant factor.

The reading of the Quevenne lactometer corresponding to any specific gravity is equivalent to 1000 Sp. gr. — 1000 and consequently the lactometer reading for pure butter fat, having a specific gravity of .93, is — 70. The lactometer reading for mixtures of milk serum and fat, such as occur in milk, must lie between y, the reading for pure serum, and — 70, the reading for pure fat, and will approach the latter figure directly as the proportion of fat increases. Starting with pure serum and increasing the proportion of fat until the serum is entirely replaced the total range of lactometer degrees passed over will be represented by the difference between y and — 70, or as y is always greater than 1, by y + 70. As lactometer readings depend upon the relative weights of equal volumes of the substance consid-

ered this differece, y + 70, will represent the change in lactometer degrees caused by 100 volume per cent. of fat and the effect of 1 volume per cent. of fat will be

$$\frac{y + 70}{100}$$

This expression multiplied by the volume per cent. of fat (f′) in any milk gives

$$\frac{y + 70}{100} f'$$

which is the difference in lactometer degrees between the reading for any milk (L) and the reading for the serum of that milk (y) and because L is always less than y,

$$y = L + \frac{y + 70}{100} f'$$

and by reducing

$$y = \frac{100\ L + 70\ f'}{100 - f'}$$

If this expression for the lactometer reading be divided by a constant number (a′) which represents the change in lactometer reading caused by 1 per cent. of serum solids the result will be the per cent. of solids in the serum. Introducing this factor and the formula becomes:

$$\text{Per cent. of solids in the serum of any milk} = \frac{100\ L + 70\ f'}{(100 - f')\ a'}$$

This is only correct for volume per cents. of fat, if, however, it be assumed that the volume and weight per cents. are equal and the value of the constant a′, in the above formula be determined, on this basis, from the average of a large number of analyses of milk the expression will be correct for weight per cent., for all milks containing this average per cent. of fat. Moreover, as the ratio of volume per cent. to weight per cent. is small and the extreme limits for fat differ but a few per cent. from the average, it is approximately true for all milks. The value of a′ derived in this way, from the average of the analyses upon which the general formula given above is based, is approximately 3.8. If this value be substituted for a′ in the last equation

considering $f' = f$ and the expression be multiplied by the per cent. of serum $(100 - f)$ and divided by 100 the result will be the per cent. of solids not fat in the milk, or

$$\text{Solids not fat} = \frac{100\ L + 70\ f}{(100 - f)\ 3.8} \times \frac{100 - f}{100}$$

and by reducing

$$\text{Solids not fat} = \frac{L + .7\ f}{3.8}$$

in which L = Quevenne lactometer reading and f = per cent. of fat.

EXCHANGES.

The Station takes pride in the fact that it has on file an almost complete list of the leading agricultural papers in the United States, besides several from foreign countries, and some not strictly treating of agriculture. These papers come to the Station in exchange for its reports and bulletins. While of he highest value to those connected with the Station as the expression of agricultural experience and sentiment, they are placed where they can be read and referred to by the agricultural students and others of the University, as well as by visitors. Any one desiring sample copies of these papers can secure them upon application to the publishers, at the addresses herewith given.

FOREIGN EXCHANGES.

Aakerbruket och Husdjursskoetseln, Kalmar, Sweden.

Agricultural Gazette, London, England.

Australian Ironmonger, Melbourne, S. Australia.

Bell's Weekly Messenger, London, England.

Bulletin Des Seances de la Societe Nationale D'Agriculture de France, Paris, France.

Canadian Livestock and Farm Journal, Toronto, Canada.

Extrait des Travaux de la Soc. Centr. d'Agr. de la Seine Infer. Rouen, France.

Farmer's Advocate, London, Ontario.

Fuehling's Landwirthschaftliche Zeitung, Leipsic, Germany.

Journal für Landwirthschaft, Berlin, Germany.

Journal of Agriculture, Montreal, Canada.

Journal of Royal Agricultural Society of England, London, Eng.

Kgl. Landtbruks-Akademiens Handlingar och Tidskrift, Stockholm, Sweden.

Landwirthschaftliche Wochenblatt, Kiel, Germany.

Le Messager Agricole, Paris, France.

L'Industrie Laitiere, Paris, France.
Live Stock Journal, London, England.
Maritime Agriculturist, Dorchester, N. B.
Milch-Zeitung, Bremen, Germany.
North British Agriculturist, Edinburgh, Scotland.
The Analyst, London, England.
The Dairy, London, England.
The Field, London, England.
The Nor' West Farmer, Winnepeg, Manitoba.
Tidsskrift for Landoekonomi, Copenhagen, Denmark.
Ugeskrift for Landmaend, Copenhagen, Denmark.
Ulster Agriculturist, Belfast, Ireland.
Zeitschrift für Nahrungsmittel-Untersuchung und Hygiene, Vienna, Austria.
Zeitschrift des Landw. Vereins in Bayern, Munich, Germany.

DOMESTIC EXCHANGES.

Acker und Gartenbau-Zeitung, Milwaukee, Wis.
American Agriculturist, New York, N. Y.
American Creamery, Chicago, Ill.
American Cultivator, Boston, Mass.
American Dairyman, New York, N. Y.
American Gardening, New York, N. Y.
American Grange Bulletin, Cincinnati, O.
American Homestead, Omaha, Neb.
American Swineherd, Chicago, Ill.
Boston Weekly Globe, Boston, Mass.
Breeder's Gazette, Chicago, Ill.
Bulletin of the American Devon Cattle Club, Wheeling, W. Va.
Connecticut Farmer, Hartford, Conn.
Creamery and Dairy, Clarksville, Iowa.
Creamery Journal, Waterloo, Iowa.
Dairy Messenger, Chicago, Ill.
Der Deutsch-Amerikanische Müller, Chicago, Ill., and New York City.
Drainage and Farm Journal, Indianapolis, Ind.
Elgin Dairy Report, Elgin, Ill.
Farm and Fireside, Philadelphia, Pa., and Springfield, Ohio.
Farm and Home, Springfield, Mass., and Chicago, Ill.
Farmers' Home, Dayton, Ohio.
Farm, Field and Stockman, Chicago, Ill.
Farm Implement News, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farmer's Review, Chicago, Ill.
Farm, Stock and Home, Minneapolis, Minn.
Garden and Forest, New York, N. Y.

Grange News, Old Harmony, Ill.
Hoard's Dairyman, Ft. Atkinson, Wis.
Holstein-Friesian Register, Brattleboro, Vt.
Home and Farm, Louisville, Ky.
Hospodar, Omaha, Neb.
Indiana Farmer, Indianapolis, Ind.
Industrial American, Lexington, Ky.
Industrialist, Manhattan, Kas.
Jersey Bulletin, Indianapolis, Ind.
Kansas Farmer, Topeka, Kas.
Live Stock Indicator, Kansas, Mo.
Live Stock Report, Chicago, Ill.
Lodi Valley News, Lodi, Wis.
Louisiana Planter, New Orleans, La.
Manitowoc Tribune, Manitowoc, Wis.
Mirror and Farmer, Manchester, N. H.
National Provisioner, New York, N. Y.
National Stockman, Pittsburg, Pa.
Nebraska Farmer, Lincoln, Neb.
New England Farmer, Boston, Mass.
New England Homestead, Springfield. Mass.
Northwestern Agriculturist, Minneapolis, Minn.
Ohio Farmer, Cleveland, Ohio.
Orange Judd Farmer, Chicago, Ill.
Pacific Rural Press, San Francisco, Cal.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago, Ill.
Proceedings of the American Philosophical Society, Philadelphia, Pa.
Rural Life, Waterloo, Iowa.
Rural New-Yorker, New York, N. Y.
Sheboygan County News, Sheboygan Falls, Wis.
Skördemannen, Minneapolis, Minn.
Southern Cultivator, Atlanta, Ga.
Southern Live Stock Journal, Starkville, Miss.
St. Croix Republican, New Richmond, Wis.
Sugar Beet, Philadelphia, Pa.
Texas Farm and Ranch, Dallas, Texas.
The Farmer's Institute, Mason City, Iowa.
The Husbandman, Elmira, N. Y.
United States Miller, Chicago, and Milwaukee, Wis.
Vick's Illustrated Monthly Magazine, Rochester, N. Y.
West American Scientist, San Diego, Cal.
Western Farmer and Stockman. Sioux City, Iowa.
Western Garden and Poultry Journal, Des Moines, Iowa.

Western Resources, Lincoln, Neb.
Western Rural, Chicago, Ill.
Western Stockman and Cultivator, Omaha, Neb.
Western Swineherd, Genesee, Ill.
Wisconsin Agriculturist, Racine, Wis.
Wisconsin Farmer, Madison, Wis.
Wisconsin Weather and Crop Journal, Milwaukee, Wis.
Wool and Hide Shipper, Chicago, Ill.

STUD BOOKS, HERD BOOKS AND FLOCK REGISTERS.

The agricultural library now contains 370 volumes of stud books, herd books, flock records and registers. Large additions have been made the past year, mainly through the thoughtful kindness of the secretaries of the various associations.

Our library is open during all business hours to parties desiring to use it for reference, and the owners and lovers of good stock are urged to make free use of these as well as all other books in the library. Those desiring assistance relative to pedigrees will be furnished the desired information whenever possible.

It is with much pleasure we acknowledge to the various secretaries the following additions during the past year:

HERD BOOKS.

Dominion Draught Horse Stud Book of Canada, vols. A and B.
Jas. Mitchell, Sec., Goderich, Can.

The Cleveland Bay Stud Book, vols. 1–7, complete.
Wm. Scarth Dixon, Sec., Micklegate, York, Eng.

The Clydesdale Stud Book of Canada, vols. 1–4, complete.
Henry Wade, Sec., Toronto, Can.

The Clydesdale Stud Book, vols. 1–13, complete.
Archd. McNeilage, Glasgow, Scotland.

Stud Book of the Select Clydesdale Horse Society of America, vol. 1.
J. B. McLaughlin, Sec., Topeka, Kas.

The National Register of French Draught Horses, vols. 1–6, complete.
C. E. Stubbs, Sec., Fairfield, Iowa.

American Jack Stock Stud Book, vol. 1.
W. L. Goodpasture, Sec., Nashville, Tenn.

Jersey Herd Book (Island of Jersey), vols. 1–10, complete.
Joshua Le Gros, Sec., St. Helier, Island of Jersey.

English Guernsey Herd Book, vols. 1–7, complete.
Julian Stevens, Sec., Grovehouse, Churchend, Eng.

Davy's Devon Herd Book, vols. 1–13, complete.
John Risdon, Jr., Sec., Wiveliscombe, Eng.

Herd Book Dutch Belted Cattle Association, vols. 1–3, complete.
H. B. Richards, Sec., Easton, Pa.

Red Polled Herd Book, vols. 1–3, complete.
J. McLain Smith, Sec., Dayton, Ohio.

American Hereford Record, vols. 1–11, complete.
C. R. Thomas, Sec., Independence, Mo.

American Aberdeen Angus Herd Book, vols. 1–3, complete.
Thos. MaFarlane, Sec., Iowa City, Iowa.

Record of the American Branch Association of the North Holland Herd Book, vols. 1–2, complete.
Fred. H. Beach, Sec., Dover, N. J.

Herd Book of the Maine State Jersey Cattle Association, vol. 5, only.
N. R. Pike, Sec., Winthrop, Maine.

Herd Register American Guernsey Cattle Club, vols. 1–3, bound, parts 13, 14, complete.
Edward Norton, Sec., Farmington, Conn.

The Ayershire Record, New Series, vols. 1–8, complete.
C. M. Winslow, Sec., Brandon, Vt.

American Devon Record, vols. 1–4, complete.
L. P. Sisson, Sec., Wheeling, W. Va.

American Galloway Herd Book, vol. 4, only.
L. P. Muir, Sec., Independence, Mo.

Oxford Down Flock Book, vols. 1–3, complete.
R. Henry Rew, Sec., Norfolk House, London, Eng.

The Hampshire Down Flock Book, vol. 1, complete.
J. E. Rawlence, Sec., Salisbury, Eng.

Suffolk Sheep Society Flock Book, vols. 1–5, complete.
Ernest Prentice, Stowmarket, Suffolk, England.

Improved Black Top Merino Record, vols. 1 and 2, complete.
L. M. Crothers, Sec., Crothers, Pa.

American Shropshire Sheep Record, vols. 1–5, complete.
Mortimer Levering, Sec., La Fayette, Ind.

American Southdown Record, vols. 1–3 complete.
S. E. Prather, Sec., Springfield, Ill.

Flock Record, of the Hampshire Down Sheep, 1 vol., complete.
John I. Gordon, Sec., Mercer, Pa.

American Oxford Down Record, vols. 1–4, complete.
W. A. Shafor, Sec., Middletown, Ohio.

The Dickinson Spanish Merino Sheep Register, vol. 1, complete.
H. G. McDowell, Sec., Camden, Ohio.

The American Cotswold Record, vols. 1–4, complete.
Geo. Harding, Sec., Waukesha, Wis.

Missouri Merino Sheep Association Register, vol. 1.
H. V. Pugsley, Sec., Plattsburg, Mo.

United States Merino Sheep Register, vols. 1 and 2.
A. E. Sprague, Sec., Reynoldsburg, Ohio.

American Merino Sheep Register, vol. 1.
A. H. Craig, Sec., Caldwell, Wis.

Register of the Michigan Merino Sheep Breeders' Association, vols. 1 and 2, Pt. 3, complete.
E. N. Ball, Sec., Hamburg, Mich.

Register of the Vermont Merino Sheep Breeders' Association, vols. 2 and 3, complete.
Albert Chapman, Sec., Middlebury, Vt.

Black Top Spanish Merino Sheep Record, vols. 1 and 2. complete.
W. G. Berry, Sec., Hustonville, Pa.

Wisconsin Sheep Breeders' and Wool Growers' Association Report and Merino Sheep Register, vols 1 and 2.
H. J. Wilkinson, Sec., Whitewater, Wis.

Register of Standard American Merino Sheep Breeders' Association, vol. 1, complete.
John P. Ray, Sec., Hemlock Lake, N. Y.

British Goat Society Herd Book, vol. 1, parts 1 and 2.
H. S. Holmes Pegler, Sec., Hemel Hempstead, Eng.

British Berkshire Herd Book, vol. 1–7, complete.
Heber Humfrey, Sec., Shippon, Eng.

American Berkshire Record, vols. 1–10, complete.
Phil. M. Springer, Sec., Springfield, Ill.

American Poland China Record, vols. 1–11, complete.
John Gilmore, Sec., Vinton, Iowa.

Ohio Poland China Record, vols. 8–11
Carl Freigau, Sec., Dayton, Ohio.

Central Poland China Record, vols. 1–11, complete.
W. H. Morris, Sec., Indianapolis, Ind.

Standard Poland China Record, vol. 1.
Ira K. Alderman, Sec., Maryville, Mo.

Record of Todd's Improved Chester White, vols. 1–3, complete.
Carl Freigau, Editor, Dayton, Ohio.

Improved Essex Swine Record, vol. 1.
W. M. Wiley, Sec., New Augusta, Ind.

The Cheshire Herd Book, vol. 1.
E. W. Davis, Sec., Oneida, New York.

The Chester White Record Association, vol. 1.
W. H. Morris, Sec., Indianapolis, Ind.

American Duroc-Jersey Record, vols. 1–3, complete.
S. E. Morton, Sec., Camden, Ohio.

ACKNOWLEDGMENTS.

The Station is glad to receive seeds or plants of new varieties, and when possible will give the same an impartial trial, announcing the results in its reports. Other articles, as machinery or materials of agricultural interest, will be received and placed among our exhibits; acknowledgment of them in the report and exhibition will be considered as discharging the obligations of the Station to the donors.

In case of articles which appear of sufficient general interest to merit it, appropriate tests will be instituted, provided the other work of the Station will permit, and the results of such tests published for the information of the farmers of the state. In no case, however, will the Station recommend and endorse any such article otherwise than as above stated, by publishing the results of actual tests.

A. DeGhequier, representative of German Kali Works, Washington, D. C., specimens of Stassfurt minerals.

Sherman Hall & Co., Chicago, Ill., samples of wool, showing classifications of Chicago market.

Frank J. Tripp, Chicago, Ill., 6 224 lb. sacks Genessee dairy salt.

L. J. Petit, Milwaukee, Wis., 15 56 lb. sacks of Diamond Crystal dairy salt.

R. M. Boyd. Racine, Wis., 1 bbl. Vacuum Pan dairy salt.

Creamery Package Co., Chicago, Ill., one set sample butter packages.

D. H. Roe & Co., Chicago, Ill., one eight bottle Babcock test; one gallon Hansen's Rennet extract; one gallon Hansen's Cheese color.

J. H. Monrad, western agent Chr. Hansen's laboratory, use of one Monrad fermentation test in dairy school.

F. B. Fargo & Co., Lake Mills, Wis., one 15 bottle Babcock test; use of one Automatic Butter Worker in dairy school.

Cornish, Curtis & Greene, Ft. Atkinson, Wis., one 15 bottle Babcock test.

A. J. Decker & Co., Fond du Lac, Wis., one 20 bottle Babcock test.

Vermont Farm Machine Co., Bellows Falls, Vt., one 12 bottle Babcock test; use of butter extractor in dairy school.

A. H. Barber & Co., Chicago, Ill., 5 gallons Van Hasselt's rennet extract.

Western Dairy Supply Co., Chicago, Ill., 1 gallon rennet extract; 1 gallon cheese color; 1 gallon butter color.

P. M. Sharples, West Chester, Pa., use of Turbine Russian separator in dairy school.

Davis & Rankin, Chicago, Ill., use of Jumbo separator in dairy school.

DeLaval Separator Co., New York City, use of Alpha Belt separator in dairy school.

Dow & Son, Millers, Madison, Wis., samples of buckwheat hulls and shorts and rye shorts.

J. G. Heaton, Reedsburg, Wis., samples of buckwheat bran and buckwheat middlings.

Stillman, Wright & Co., Berlin, Wis., samples of buckwheat bran, buckwheat shorts and buckwheat middlings.

Rockford Oatmeal Co., Rockford, Ill., samples of oat shorts, oat dust, "ground feed."

Pabst Brewing Co., Milwaukee, Wis., samples of malt sprouts, brewers' grains, barley feed.

Rockford Sugar Works, Rockford, Ill., samples of gluten meal and starch refuse.

E. W. Blatchford & Co., Chicago, Ill., one sample of locust bean meal.

Jackson Oil Mills, Jackson, Tenn., samples of cotton seed hulls and cotton seed meal.

Bryce's Baking Co., Chicago, Ill., one sample of bread meal.

Apple cions from Clark Hewitt, Waupun, Wis.; A. W. Sias, Rochester, Minn.; Peter M. Gideon, Excelsior, Minn.; Prof. Jas. Troop, LaFayette, Ind.; O. F. Brand, Faribault, Minn.; Geo. P. Peffer, Pewaukee, Wis.; O. C. Cook, Oconto, Wis.; J. S. Stickney, Wauwatosa, Wis.; E. R. McKinney, Lacon, Ill.; M. L. Tibbetts, Dover, Minn.; W. J. Grunnewald, Blairstown, Iowa; H. E. Van Deman, Dept. of Agr., Washington, D. C.; A. J. Phillips, West Salem, Wis.; and J. B. Farmer. Dale, Wis.

Cherry cions from W. S. Wood, Shawano, Wis.

Plum Cions, from W. S. Wood, Shawano, Wis.; J. S. Parks, Pleasant Mounds, Minn.; A. W. Sias, Rochester, Minn.; T. J. Van Matre, Mineral Point, Wis.; C. W. H. Heideman, New Ulm, Minn.; J. S. Harris, La Crescent, Minn.; B. H. Smith, Shopiere, Wis., and H. E. Van Deman, Dept. of Agr., Washington, D. C.

Seeds and tubers, from Dep't of Agriculture, Washington, D. C.; Steele Bros. & Co., Toronto, Ontario; Wm. Henry Maule, Philadelphia. Pa.; Thos. Crane, Ft. Atkinson, Wis.; J. C. Vaughan, Chicago, Ill.; Wm. Watson, Turlington, Neb.; Mark W. Johnson Seed Co., Atlanta, Ga.; Francis Brill, Hempstead, L. I.: Jos. Harris Seed Co., Moreton Farm, Rochester, N. Y.; F. Barteldes & Co., Lawrence, Kas.; J. B. Rice & Co., Cambridge, N. Y.; and D. M. Ferry & Co., Detroit, Mich.

Plants, trees and vines from E. R. McKinney, Lacon, Ill.; Geo. S.

Josselyn, Fredonia, N. Y.; Secretary of Agriculture, Washington, D. C.; J. A. Dobbins, Barnesville, O.; Julius Schnadelbach, Grand Bay, Ala.; Geo. Williams, Waupaca, Wis.; E. W. Cruse, Leavenworth, Kansas; C. E. Hunn, Expt. Station, Geneva, N. Y.; Adna Sawyer, Delavan, Wis.; I. Gale & Son, Waukesha, Wis., and S. D. Richardson & Son, Winnebago City, Minn.

Geranium cuttings from I. F. Gale, Waukesha, Wis.

Willow cuttings from J. S. Stickney, Wauwatosa, Wis.

Currants from E. G. Lodemann, Cornell University, Ithaca, N. Y.

Apples from O. C. Cook, Oconto, Wis., and Dr. M. L. Barney, Hartford, Wis.

Grafting wax from T. Greiner, LaSalle, N. Y.

Little Climax pump, from Nixon Nozzle & Machine Co., Dayton, O.

Acme hand potato planter, from Traverse City Potato Planter Mfg. Co., Traverse City, Mich.

Models for instruction, from A. L Hatch, Ithaca, Wis., and Wells, Higman & Co., St. Joseph, Mich.

Acme Cement Plaster Co., Salina, Kan., 2 sacks Acme cement plaster.

Carbolineum Wood Preserving Co., Milwaukee, Wis., 1 can Carbolineum Avenarius.

International Seed Co., Fond du Lac, Wis., half bushel White Russian oats.

Ontario Agricultural College, Guelph, Ontario, Prof. Shaw, sample of Mandscheuri barley and Joanette Black oats.

FINANCIAL STATEMENT.

The Wisconsin Agricultural Experiment Station, in Account with the United States Appropriation.

1891.	Page.	Cr.	Dr.
To receipts from treasurer of the United States, as per appropriation for the year ending June 30, 1891, under act of Congress, approved March 2, 1887	9	....	$15,000 00
By Salaries	23	$6,000 00	....
Labor	33	3,637 47	....
Laboratory supplies	43	348 58	....
Farm supplies	53	475 99	....
Freight and express	63	178 22	....
Postage and office supplies	73	429 69	....
Library	83	37 13	....
Farm implements	93	447 04	....
Apparatus	103	614 96	. ...
Furniture	113	17 77	....
Fencing and drainage	123	285 83	....
Seeds and plants	133	16 26	... .
Live stock	143	223 00	....
Feed	153	954 10	....
Traveling	163	173 33	....
Fuel and light	173	301 65	....
Incidental expenses	183	113 50	... .
Building and repairs	193	745 48	....
		$15,000 00	$15,000 00

I hereby certify that the foregoing statement is a true copy from the books of account of the institution named.

E. F. RILEY,
Secretary Board of Regents,
University of Wisconsin.

Madison, Wisconsin, July 24, 1891.

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